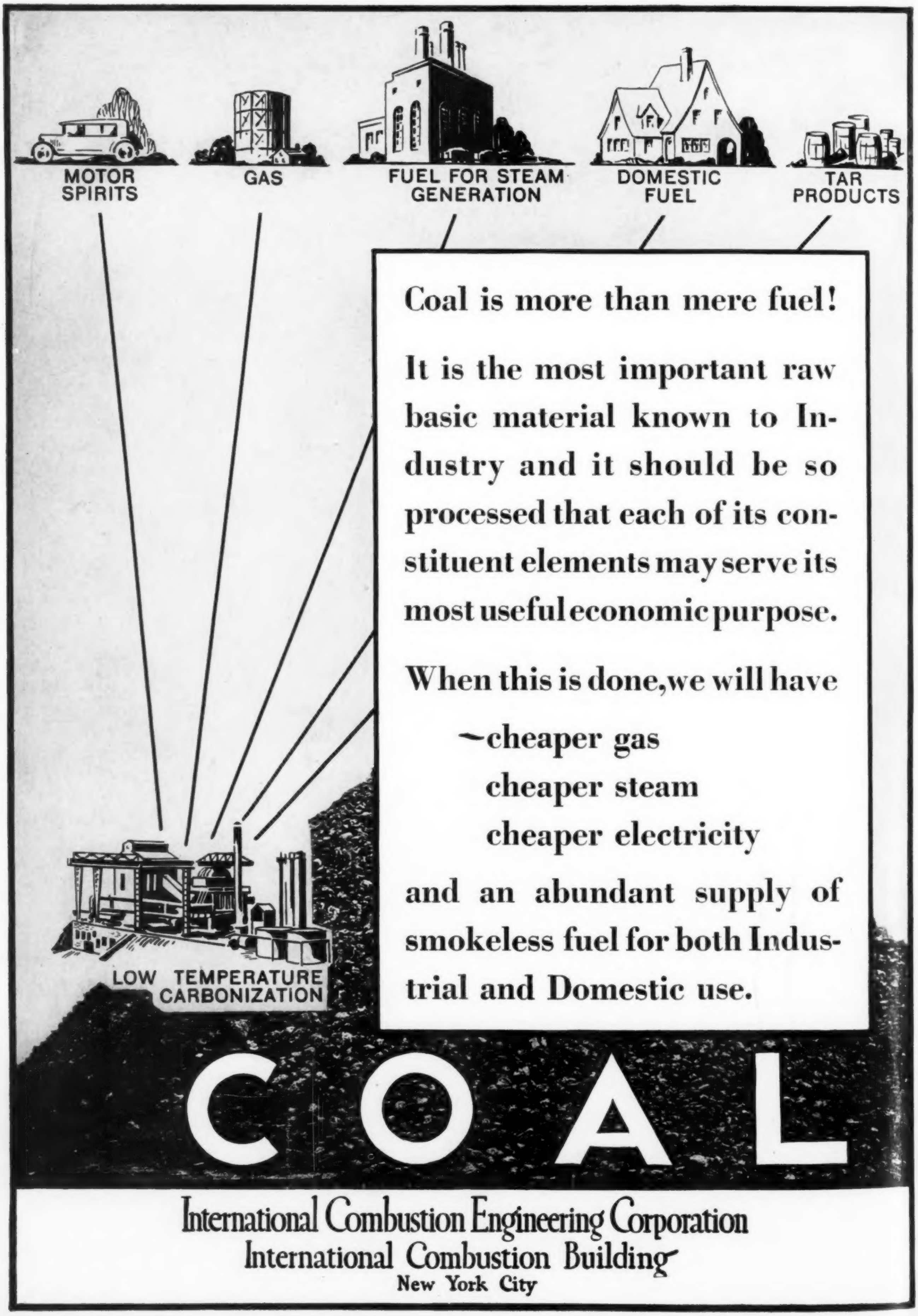
MECHANICAL ENGINEERING

May 1928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Mechanical Engineering

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DEPARTMENTAL

ADVERTISING

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H. G. Reist

E. F. DuBrul

A. D. Turnbull

A. C. Jewett

H. K. Hitchcock

Contributors to This Issue

A. D. Turnbull is a graduate of the U.S. Naval Academy and has seen a considerable amount of engineering duty in the Navy. During the war he commanded an escort and patrol squadron on the French coast, and served on the staff of Admiral Sims at Naval Headquarters, London. He left the Navy in 1920 with the rank of commander. He is the author of short fiction stories, articles, etc., and of the forthcoming biography of Col. John Stevens.

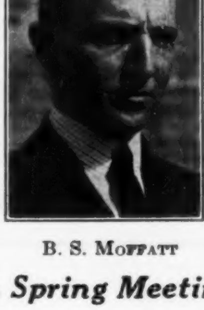
A. C. Jewett, director of the College of Industries of the Carnegie Institute of Technology since 1925, was graduated from the Massachusetts Institute of Technology in 1901. He served for two years as instructor in the University of Maine, and from 1905 to 1914 held the chair of mechanical engineering there. He was for two years associated with Bird & Son, East Walpole, Mass., and from 1916 to 1924 held successively the positions of production superintendent, superintendent of engineering, and superintendent of personnel with the Winchester Repeating Arms Co. He devoted about a year to the study of engineering education for the National Industrial Conference Board, a bulletin of which was published in 1905.

E. F. DuBrul, secretary and general manager since 1921 of the National Machine Tool Builders' Association, was graduated in 1892 from Notre Dame University, later doing graduate work at Johns Hopkins University. He holds the degrees of A.M., Litt.M., and LL.B. He was associated for a number of years as secretary and as vice-president with the Miller, DuBrul & Peters Manufacturing Co., Cincinnati, becoming president in 1915. During the war he served in the "Training and Dilution Service" of the U.S. Department of Labor in the Cincinnati Region. He retired from active business in 1919 and took his present position two years later at the request of the directors of the Association.

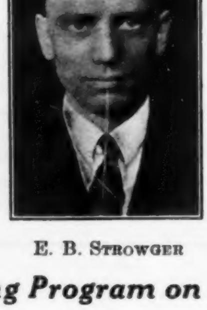
H. K. Hitchcock, for the past eighteen years consulting engineer for the Pittsburgh Plate Glass Co., received his engineering education at Ohio State University. Upon leaving school he spent several years in electrical construction work, being associated with the Thomson-Houston Co. and other electrical concerns. In the latter part of the 90's Mr. Hitchcock went to Pittsburgh, and since then has been actively engaged in the development of various lines of glass manufacture.

H. G. Reist has had charge of the designing of alternating-current machinery for the General Electric Co. since 1894, and in this capacity has directed the construction of much of the country's large electrical machinery. He received the degree of M.E. at Lehigh University in 1886, and was given the honorary degree of Doctor of Engineering by the same institution in 1922, in recognition of his work in developing electrical machinery. During recent years he has been much interested in the use of rolled steel, instead of castings, in the building of electric generators and motors.

B. S. Moffatt was educated in the Science and Arts branch of the Mining School in England. After graduation he served an apprenticeship of five years to the machinist's trade. At the end of his apprenticeship he came to the United States and worked for several years as a machinist, toolmaker, foreman, and general foreman in the small-arms manufacturing and precision machine-tool fields. In 1922 he was appointed superintendent of machine-shop training at the California Institute of Technology. Two years later he was made supervisor of apprentice training for the Caterpillar Tractor Company, San Leandro, Calif., and Peoria, Ill., the position he holds at the present time.



B. S. Moffatt



E. B. Strowger

H. Boyd Brydon, who is the author of the paper entitled "Some Economic Factors in Power-Station Design," an abstract of which is published in this issue, holds the position of mechanical engineer with the Byllesby Engineering and Management Corporation, Chicago, Ill.

E. B. Strowger, assistant hydraulic engineer with the Niagara Falls Power Co., was graduated from the University of Rochester in 1918. For about a year he was engaged in shipbuilding work for the Interlake Engineering Co., Cleveland, then joining the staff of his present concern as draftsman and designer.

This Month's Cover is a reproduction, picturing Pittsburgh and its environs, of Otto Kuhler's etching "The Valley of Work"—particularly appropriate to this issue with its papers to be presented at the coming Spring Meeting of the A.S.M.E. in that city. Mr. Kuhler is a well-known etcher of industrial subjects. He is an engineer and a steel maker, and this engineering influence is reflected in his strong, virile treatment of the subject. The etching is reproduced through the courtesy of the Combustion Engineering Corporation, New York, N. Y.

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MECHANICAL ENGINEERING

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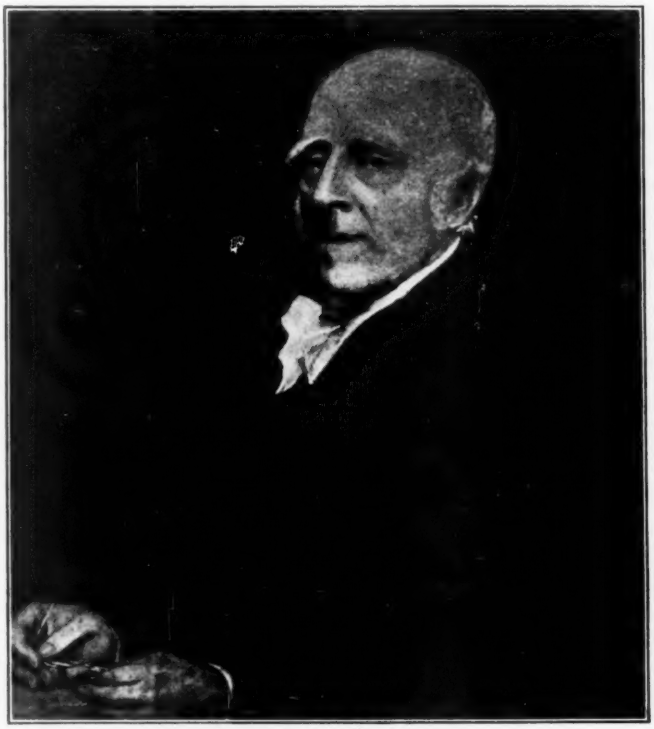
John Stevens and His Sons

Contributions to Steamboat and Rail Transportation Made by Them During the Early Days of the American Republic

By A. D. Turnbull, Morristown, N. J.

"The wealth and prosperity of a nation," said Colonel John Stevens, "depend almost entirely upon the facility and cheapness with which transportation is effected internally." His words, written in 1806, were partly the result of a keen study of economics pursued, after an original training for the law, as a soldier of Washington's army and then as treasurer of New Jersey. Living through that critical quarter-century immediately following the Revolution, he was not alone in appreciating how nearly the tremendous difficulties of travel and communication came to wrecking the efforts of statesmen to weld thirteen practically independent republics into one nation. His active mind missed nothing of the economic situation.


Colonel John Stevens

From the engineering standpoint, however, his position was much more nearly unique, for when he wrote what has been quoted he was the engineering leader of America. His was that period which Robert Louis Stevenson has aptly described as bare of those footprints and guideposts that help the modern member of the profession; those carefully prepared textbooks of stress and strain, formulas for pouring steel of certain qualities, and tables of steam pressure and hull resistance. The imaginative pioneer strode almost bare-handed into the face of nature and, as Stevenson says, "engineering was not a science then—it was a living art." It is this that makes the conceptions, accomplishments, and foresight of John Stevens worth examining.[1]

Many of his original letters are still in existence, and from these it appears that it was steam engineering which first attracted him. In 1788, John Fitch and James Rumsey were engaged in a quarrel over their respective claims to priority in designing steamboats, filling the newspapers with letters that were often bitter, and printing pamphlets containing drawings and descriptions as well as affidavits from those who were supposed to have seen the actual boats in operation. Colonel Stevens, after studying all these documents, presently reached the conclusion that something might be said for both, since each made a somewhat different application of the same fundamental principles. In his view, the principles were anybody's property and the whole question of infringement depended upon application, that is, machines. Theories advanced by Newcomen, Savery, Watt, and other early scientists were, in his opinion, fully available; it was differences in the design of engines, or in their specific improvement, which would enlarge the field for inventors without working injustice to any one of them.

At the outset, he was unfavorably impressed by Rumsey's boiler, with its long coil of a single pipe. The liability to leakage appeared evident, while the heating surface was small in relation to its size and a great unevenness in generating steam was probable. In the effort to improve upon Rumsey, he hit upon the plan of using a group of short pipes, these to be straight and screwed, at both ends, into a head. He pointed out that this combination could be used either with water inside the pipes or tubes and fire outside, or vice versa. Legend declares that his first model was made with musket barrels, but however this may be, he had in fact produced the primitive prototype of the modern multitubular boiler, as frequently re-invented in after years by European and American engineers. Experiment merely confirmed him in the opinion that the type would give great heating surface in small space, thus bringing about a very important saving in the weight of installation afloat, while at the same time generating steam rapidly and in quantity.

Confident that his boiler would prove to be a valuable property, the next question considered by the Colonel was how to reserve

[1] "A Life of John Stevens," by Archibald Douglas Turnbull, to be published by The Century Company in May, contains a more exhaustive study of the achievements of this pioneer in engineering.

that property for himself. In 1789 there were no laws to prevent one man from picking the brains of another. Obviously, said the Colonel, as more inventors entered the field, there would be more battles like that between Fitch and Rumsey, resulting in a general chaos without due profit to any one. He therefore submitted to the legislature of New York a description of his boiler and of "a method of propelling boats by steam" which was essentially a double-ended pump. For these he petitioned the legislature to grant him "an exclusive privilege" in the state. However, he soon discovered that among those who considered his petition, few, if any, had even the rudiments of mechanical knowledge. A petition from Rumsey had come in a few days earlier and the legislature, without any question of mechanical differences, acted upon the theory of first come, first served. Whatever such a privilege might have been worth to the Colonel at that moment, he did not get it.

As a student of the Federal Constitution, and the author of quite a conspicuous pamphlet upon it, the Colonel had not failed to notice the provision that Congress might "encourage progress in science and the useful arts." Bundling up the papers that had failed in New York, he presented them to Congress where he had a good many influential friends, among the members of leading Colonial families. These friends pressed his contention that the product of a man's mind was entitled to protection, with the result that the first Patent Law was finally enacted in 1790. Although it was another year before his and other early patents were actually granted by the board headed by Jefferson as Secretary of State, it is fair to call the Colonel the godfather of American inventors. His clear understanding of the patent laws is evident enough in his later correspondence with rivals who entered the steamboat field after 1800.

Stevens' First Steamboat

During the last decade of the 18th century he became associated with his brother-in-law, Chancellor Robert Livingston, and with Nicholas J. Roosevelt, collateral ancestor of the late president. These three built several experimental steam craft at the old Schuyler works in Belleville, New Jersey, and John Hewitt, father of the late mayor of New York City, declared that it was here that Colonel Stevens erected the first low-pressure, non-condensing engine of wholly American construction. John Hewitt, as the patternmaker of the works, was in a position to know, and he described to his son a trip made down the Passaic to New York, in 1798, in a boat equipped with this engine. Others on the trip included names later better known in engineering history, Smallman and Rhode, and Stoudenger who was afterward Fulton's foreman.

The performance of the boat was not a complete success. Vibration was excessive and, as the boiler developed many leaks, steam could not be maintained for any length of time. The operation of the engine led to a very strong difference of opinion between the three partners, Livingston clinging to the already somewhat outworn idea of a horizontal wheel under the keel, Roosevelt earnestly advocating the adoption of side wheels, and Stevens just as convinced that eventually the place for whatever actually propelled the boat would prove to be the stern. To this belief he became as fully committed as to the small-tube boiler, insisting that, whatever the difficulties in the way, these would eventually prove not insuperable. Fortunately for himself, he lived to see that he was right.

The first and chief difficulty was the one encountered by every one who tried to build anything in those days—the dearth of even moderately capable mechanics. Except for those already mentioned as at Belleville, almost no English mechanics came to this country. Tools, of course, had to be roughed out as they appeared to be needed, and would not hold an edge. The lathe and the boring bar were still figments of the vivid imagination. Even much later, pistons to be trued up were hauled around by a gang of men with hooks. Nobody had ever heard of micrometer gages, or carried a set of feelers in his pocket. Piston clearance was measured in such expressive but woefully vague terms as "within the thickness of a worn shilling." A thousandth of an inch was a conception as strange as the distance of the sun from the earth, and to read the early drawings and descriptions is to marvel how such contraptions ever ran at all.

The Colonel's chief encouragement came from a young Frenchman, a refugee from the Terror and none other than Marc Isambard Brunel. At a time when he could not foresee that his name would one day be connected with the Thames Tunnel and a score of inventions, or that his son Kingdom would eventually build the *Great Western*, this young man worked for whatever the Colonel could pay him, at Hoboken. It is probable that he assisted the Colonel in 1799, when the latter became consulting engineer to Aaron Burr's camouflaged bank, the Manhattan Water Company, and began the laying the wooden pipes to carry New York's water supply. He may, too, have discussed with the Colonel the design of a two-stage pump, built for this same water service after Savery's earlier one, but, unlike Savery's, equipped with a condenser. Of definite record, however, is Brunel's test of the Stevens device for obtaining greater pressure and superheated steam by exploding "spirits" inside the cylinder. Brunel's letter identifies this idea as not his own but the Colonel's, and gives some detail of the consternation among his helpers over these early efforts at internal combustion. He also notes the lack of means of scavenging the exploded gas.

The Screw Propeller

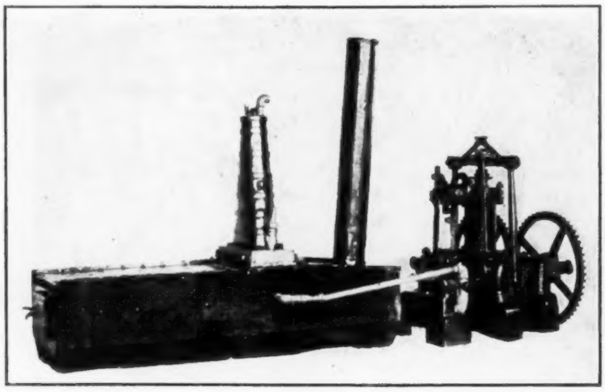
In 1800, Colonel Stevens entered into a written agreement with Livingston and Roosevelt to share in all Hudson River steamboat experiments made by any one of the three during the next twenty years. But as Livingston within a few months accepted the post of Minister to France, and as Roosevelt became increasingly interested in making guns for the new frigates, Colonel Stevens proceeded virtually alone. Having succeeded in building a rather better multitubular boiler, he made Stevens' steamboats quite a commonplace on the Hudson until, in 1804–5, he produced a real novelty. Professor James Renwick, of Columbia College, who saw this particular craft leave the Battery and cross over to Hoboken, declared that what astonished the crowd of spectators was the lack of "visible means of propulsion." The explanation is that Colonel Stevens had made the first successful application of his long-held wheel-in-the-stern theory. The screw propeller had become a fact.

The engine, still to be seen in the Smithsonian Institution, was double, and direct acting. Shackle bars, or connecting rods, suspended from a yoke at the top of the piston rod, operated through cranks and gear wheels to drive the two shafts. These shafts, at their outboard ends, carried what were afterwards sometimes derisively spoken of as "smoke-jack flies," singularly like the modern propeller blades in shape and having their entrance angle capable of adjustment. Describing his design in a letter to Dr. Robert Hare, the Philadelphia physicist, Colonel Stevens sketched his propellers as supported by outside struts; another feature well in advance of the so-called twin-screws of some thirty years later, in which one shaft was inside the other, with both passing through the stern post. The Colonel gave as his reasons for adopting two screws rather than one not only the increase in driving power but also the far better maneuvering qualities.

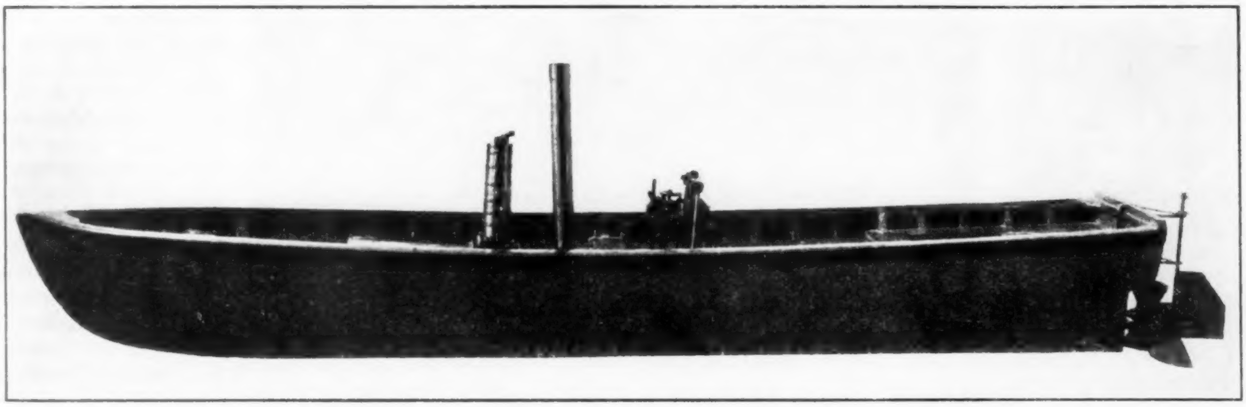
As a rule, this twin-screw craft was operated by two of the Colonel's sons. The helm was usually in the hands of John Cox Stevens, afterward so widely known as the sportsman who or-

ganized the New York Yacht Club and headed the syndicate to build the famous *America.* The engine was run by Robert Stevens, destined to become the leading American naval architect and engineer. Only seventeen at this time, he was already so deeply interested in his father's efforts that he refused to study anything but engineering. Not even the Colonel himself was more disappointed than Robert when it became apparent that no boiler of that day could be made tight enough to carry the high-pressure steam required for a propeller. He was far less philosophical than his father in accepting the idea that, until better boilers could be made, side wheels must serve to drive steamboats. Forty years later, when tighter joints were possible, he repaired this old engine and boiler, installed them in a boat that was a copy of the original, and made a speed of eight miles an hour with it—a startling performance.

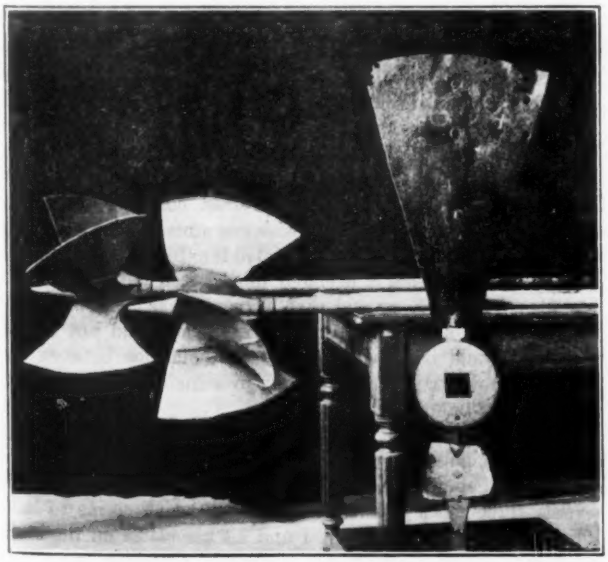
The *Phoenix*, built by Colonel Stevens in 1808, was a side-wheeler. He intended her to compete with the Livingston-Fulton craft on the Hudson. When, however, it became apparent that the amazing monopoly granted by the state of New York to Livingston and Fulton could not be broken without wearisome litigation and enormous expenditure of money, the *Phoenix* was sent to the Delaware to inaugurate the service between Philadelphia and Trenton, for so many years afterward a great Stevens activity. Going to the Delaware gave the *Phoenix* the unique distinction of making the first ocean voyage by a steamboat, an interesting cruise of which Robert Stevens, who was in charge of it, has left an account in his log. It demonstrated, to the satisfaction of the Colonel and his sons, that the Stevens engine was at least the equal of any other then afloat.



Multitubular Boiler and Steam Engine with Two Shafts



Model of the Stevens Twin-Screw Steamboat with Multitubular Boiler



The Stevens Screw Propeller

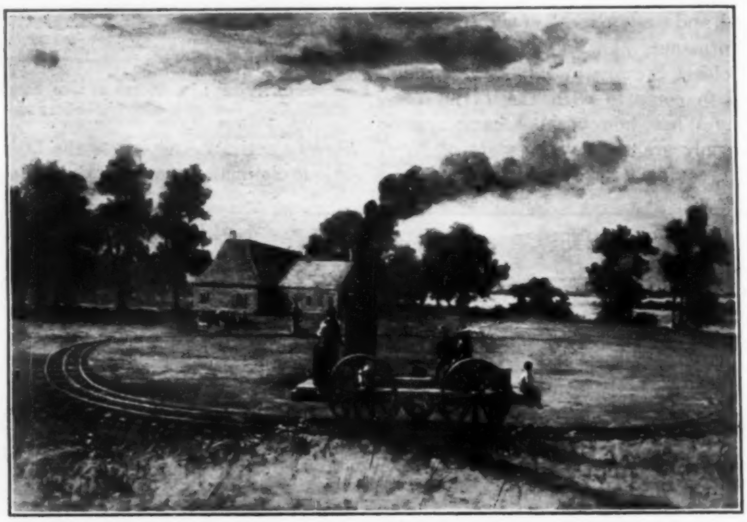
The *Juliana* was also a side-wheeler. With her, the Colonel in 1811 established the first regular steam-ferry service, running between Hoboken and New York. More than that, he forever identified his family with the Hoboken ferry, for not only did Robert design the spring-pile slips still in use, and make such improvements in engine design as the walking beam and the cut-off, but also Edwin Stevens, the Colonel's grandson, eventually solved the important problem of having screw propellers at both ends of the boats. Almost every feature of a modern Hudson River ferryboat, mechanically and in equipment, is the direct result of a contribution by one member of the family or another.

Roads, Bridges, and Tunnels

In attempting to develop the town of Hoboken, Colonel Stevens was soon engaged in road building. He constructed the causeway across the Hackensack Meadows and, after much struggle, succeeded in bringing about the building of the turnpike. As this and later roads brought travelers from the country on their way to New York, the Colonel became impressed with his vision of the future metropolis. Even before he had the *Juliana* running on the ferry, he predicted that she and her sisters would never prove sufficient to carry the future commuters. He there-

fore insisted that a Hudson bridge should be the next logical step, and submitted his own design of a floating bridge. When this met with the expected and violent opposition of shipping men, he followed it with a design for a permanent bridge, of six-hundred-foot spans, which he felt ought for many years to answer the purpose. An interesting feature of these bridge designs was his accompanying them by plans for organizing stock companies and by exhaustive estimates of cost, depreciation, and upkeep—a very early recognition of the business side of engineering. Undaunted by the general coolness toward his bridge propositions, his next suggestion was a still more radical one.

"It must be obvious," said he, "that New York will become a city of the first magnitude—and that, too, at no distant date." Insisting that communication with the mainland would be vital to the city's progress and, indeed, to her very existence, he argued that neither ferries, nor bridges, nor both together, would eventually prove adequate. He therefore proposed that a tunnel under the Hudson be begun at once. Discarding the idea of digging under the bed, he declared that the better way would be to *lay it in the bed*. As he saw it, cylinders in the form of the frustum of a cone might be built and locked together; these to be "lined with brick or hewn stone" and have a roadway laid through them. A pathway above the level of the road at one side was to serve for the pedestrians. Convinced that this must be the ultimate method of getting workers and farm produce into the city of New York, the Colonel proposed that construction be started in 1807. There could scarcely be a better example of the distance he could peer into the future.



Rack-and-Pinion Steam Carriage on Stevens' Lawn at Hoboken—The First Steam Railroad in America

An outstanding feature of all the Stevens efforts toward transportation was the aiming always at speed. While Fulton and others held that a steamboat making more than about seven knots would never be practical, the Colonel persistently maintained that the whole question was merely one of improving engines and boilers. He talked of hundred pounds to the square inch, and built for it, when steamboats were operating on four or five. He sent his son all the way to Birmingham to interview Watt and persuade him to build high-pressure boilers of the Stevens design. Even the disbelief of Watt and practically every other engineer did not wholly discourage him, and he was able to communicate his enthusiasm to his sons to such an extent that, before many years had passed, the Stevens steamboats were leading all others in speed. This was accomplished on the Hudson, to which the family craft returned as soon as Chief Justice Marshall, in 1824, had broken the Hudson Monopoly by declaring it to be wholly unconstitutional. Credit for Hudson speed belongs more particularly to the sons because the Colonel had become absorbed in another, even greater, effort toward the improvement of American transportation.

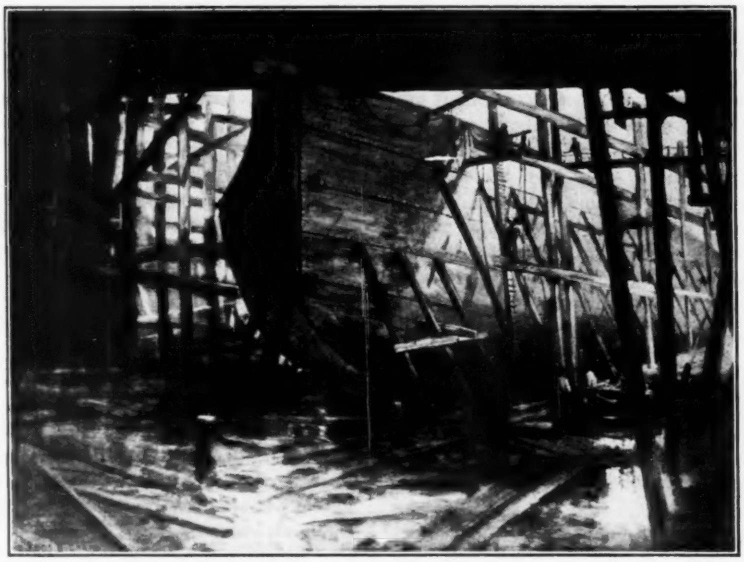
Steam Railways

"On land," he declared, "we have the problem of successfully applying the same principles of steam which have been proved on the water. Why should not the United States lead the world in steam railways?" When he began to argue in this way there was no steam railroad anywhere on earth, for the year was 1810. Moreover, the American enthusiasm over canals was rampant, and few heeded the Colonel's prediction that these would eventually prove to be a waste of money. At the best, he argued, canal transportation would be too slow for perishable freight. He urged the Canal Commission to set aside at least a few thousands to build an experimental railway, pledging himself to build it and to prove that "suites of carriages" could be operated upon it with safety and speed. "In time," he wrote, "we shall be able to travel as fast as a hundred miles an hour without inconvenience. We shall go from New York to Philadelphia in less than three hours, with ease. We shall descend valleys and climb mountains. We shall be able to transport troops to defend our frontiers in days or hours where it now requires weeks. Best of all, we shall bind our states together with unbreakable steel bands of union."

With the exception of Oliver Evans, Stevens was the only American advocate of railroads. He gathered together a number of the letters he had exchanged with all the prominent men of the day and these, with his plan as submitted to the Canal Commission and the Commission's reply, he published in a pamphlet in 1812. This was the first argument for railroads ever printed in America, and, as it was recently called by an official of the Pennsylvania System who saw it for the first time, it was the birth certificate of the nation's railroads today. When issued it did not prove convincing, but Colonel Stevens continued to send it to every public man in the country. In season and out of it he talked railroads, although his friends laughed at him and although legislators, when they saw him approaching, turned and ran. It took him five years to get the first charter for a railroad granted to him by the state of New Jersey. Even then, he had made no great headway, for the original board of directors of the company proved lukewarm to any building project and public interest consequently lagged far behind. Governor Clinton, who was among those whom the Colonel sought to interest, disappointed him by treating railroads as a chimera. Jefferson declared himself too old to take up a new idea. Rufus King said that Congress was "too busy this session" to do anything about it. Livingston did not believe that frost could be guarded against or collisions between the carriages prevented. Other equally prominent men were afraid of the cost of building and operating.

But Colonel Stevens was not easily discouraged. Persisting in his efforts, he finally obtained, in 1823, a second charter, this time from Pennsylvania. This contemplated building a line seventy-three miles in length, a distance which seems to have staggered even Stephen Girard and his associates on the original board of the Pennsylvania Railroad. Outsiders who were asked to subscribe to the stock were stunned by such a colossal

plan of building, and the funds were not forthcoming. It is, however, a fact that under this charter, somewhat modified by subsequent legislatures, the Pennsylvania System was eventually begun. This was not until about the time that the Stephensons in England had produced the *Rocket* and thus convinced even the most doubtful that steam railroads were entirely practicable. Five years earlier, Colonel Stevens had built his own railroad on the lawn at Hoboken and erected upon it a small steam carriage, moving along rails fitted with a rack and pinion gear. He made all his guests ride in this carriage, and, while it was not built for commercial purposes, it was actually the first steam railroad on this side of the Atlantic. As far as he could personally manage it, the Colonel did secure for America the leadership in railway building. Had he had his way, the nation might have gained a dozen years upon the start it eventually made.



The First Known "Ironclad"

As in steamboats, so in railroads the Colonel's enthusiasm was shared by his sons. The Camden and Amboy, first road in New Jersey, was organized mainly by Edwin Stevens, with Robert as its construction engineer. In 1830 Robert went to Europe to buy what was believed to be better iron than could be manufactured here for rails. During the crossing he studied the existing designs of rails, and eventually whittled from a wooden block a model for what has since become the American standard—the T-rail. Except for a relatively slight difference in the radius of the fillets, and for variations in weight per foot, this modern rail is the counterpart of the original. It was rolled at the Guest Iron Works, in Dowlais, Wales, that firm being the only one willing to risk its rolling mills on the new design, even with a heavy bond against breakage, furnished by Robert. When it arrived in this country, the first shipment was laid upon stone blocks but, as the supply of these ran short, Robert resorted to an expedient. He laid the rails on logs, placed crosswise and bedded with small rock, using a hook-headed spike designed by himself to hold the rails in place. This is of course easily recognized as the modern method, adopted because the first train over the new rails made the great improvement in roadbed instantly apparent. Thus it fell to Robert Stevens to contribute enormously to the realization of his father's dream of America's future in railroads, just as his strides in the design of steamboats proved everything that his father had claimed for speed afloat.

Similarly, the economic side of Colonel Stevens' conceptions often found expression through his son Edwin. Although the latter was not without his achievements as an inventor—for example, he devised the first "closed fire-room" system of forced draft—his main interest lay on the side of organization and financing. Frequently, as improvement in materials and machines made it possible, Robert undertook to carry out some much earlier idea of his father's, while Edwin found the necessary funds. Thus the first known ironclad, laid down by the brothers about ten years before the Civil War, represented a conception of the Colonel's in 1812, while Edwin's founding of the Institute of Technology was the direct result of an "academy of science" which his father had never been able to afford building. Unfortunately, although he lived to be ninety, and so saw the great era of steamboats and railroads fairly started, the Colonel missed seeing the Institute actually begun. But it is properly to be included in the record of a family that must be unique in engineering history for genius of invention, farsightedness, and positive accomplishment in the great American field of transportation afloat and ashore. Theirs was a distinct contribution to "the wealth and prosperity of the nation."

A "Woodless" House

For the residence of Walter Bates, president of the Walter Bates Steel Corporation, at Gary, Ind., the General Construction Company is completing a house $55^1/_2$ ft. long by 45 ft. wide "without a stick of wood in it."

The design provides for specially braced all-steel construction, using for the framework the same kind of angle-iron members, with sheared and expanded edges, as are used in the Bates type of electric-transmission tower and pole construction. As shown in photographs accompanying the article, strips sheared along the angle-iron edges (the cut extending not quite to the ends of the member in order to provide enough metal to hold the parts together) are utilized to provide an unusually complete system of diagonal bracing.

In the concrete foundation, which was coated on the outside with water-proofing, bolts were cast to anchor the steelwork. For the most part the steel framework of the house was bolted together, although there were places in which electric welding was employed.

The floors of the house are of 2-in. concrete slabs, to which carpeting is directly applied without the use of any wood. The concrete floors, it is pointed out, are desirable not only from a sanitary and fireproof point of view, but also from the point of view of stiffening the structure. The floors are carried on Bates expanded-steel floor joists, through which pipe and conduit may be run without cutting.

Carrying out the idea of all-metal construction, the stairs and window sash are all of steel. (*Construction News*, vol. 10, no. 3, March, 1928, pp. 34–35, illustrated)

Sources of Power

FROM time to time the popular press and occasionally even an engineering publication start talking about some new kind of prime mover operated by electricity taken from the air or a new combination of windings, or by some radically new form of energy. Even engineers are beginning to consider as a possibility the utilization of energy liberated in some as yet obscure manner by the breakdown of the atom. In view of all this it becomes of interest to consider just how and why the sources of energy that are used in present engineering are available.

The earth on which we live is very, very old. The more we learn about it the further back are shifted its beginnings. Where fifty years ago science talked about the earth's age as being of the order of 1,000,000 to 5,000.000 years, today geologists confidently put its age at a minimum of 100,000.000 years, and there are already reasons apparent to make it believable that even this span of time is a low estimate when it comes to the true age of the earth.

During this enormous period of time even very slow chemical and physical reactions could have been accomplished. We find, therefore, that wherever a material could have combined with any other material in its immediate neighborhood, it did so combine. This is the reason why most of the ores are found in the form of sulphides, phosphides, oxides, etc. Virgin iron is practically unknown; virgin copper is met in only a few places where protection chiefly by sand kept away from it all those other elements that would have been willing to enter into a combination with it.

Another very significant feature of the chemical composition of the earth's crust is that, whenever possible, materials are encountered therein not in their intermediary unstable or semistable combinations, but in the most stable form, thus indicating that whenever possible, chemical action continued as long as it could. Chemically (with such exceptions as will be noted below) the earth's crust is in a state of stable equilibrium.

When we consider the same crust mechanically we again find a clear tendency toward the same stable balance. Today "even the weariest river runs safely to the sea." This was not so always. Geologic formations indicate that in days far gone by there were wide lakes opening into huge waterfalls. About 100 miles from the present ending of the Hudson River the sea bottom shows traces of a big waterfall into which this river formerly discharged. As millions of years followed each other, however, the surface wore down, and where there was an abrupt change of level formerly, today mostly a uniform descent is only to be seen. There are still a few waterfalls here and there, Niagara Falls in North America, Imatra in Finland, the Victoria Nyanza in Central Africa, but these are simply survivals of a distant age, and for example, the Niagara Falls, even within the brief memory of the white man on the American continent, has lost some of its height of fall. The general mechanical tendency in nature is to accomplish within wide limits the same state of balance as is observed in the chemical composition.

What sources of energy have hitherto been available to humanity in large quantities may be said to be those which have been specially locked up within the earth's crust. There was a time when practically the entire face of the earth was covered by luxurious vegetation. This has been, however, burned, rotted, or otherwise destroyed by oxidation, either violently induced or of slower process as under water, or in a modified form by the action of bacterial life. It is only here and there that primeval forests have been covered over by layers of earth in such a manner as to prevent the access of oxygen thereto. From the point of view of chemical history of the earth this was an irregularity, because combinable carbon did not enter into such a combination with oxygen as would bring the two to the most stable form. When we dig out the coal, place it under boilers, and burn it to carbon dioxide, we accomplish for a commercial purpose the very same thing that has been going on for some purpose unknown to us during all of the hundred million years of the history of the earth.

In other words, we can generate power only by finding in nature something that has not yet reached its most stable condition, and helping it to do so. It so happens that all such reactions are exothermic, which means that they produce energy rather than consume it. That is what happens when we burn coal under a boiler or explode a mixture of oil and air in a cylinder. The only reason why nature has not done it before we had a chance to is that the two materials whereof the reaction produces heat or energy have not been sufficiently close together. Coal and oil have been protected underground from the action of the oxygen. We bring them up and place them in contact with that oxygen, whereupon the reaction takes place with its consequent generation of power.

When we come with the above in mind to the consideration of the so-called interatomic energy and consider, for example, the simplest molecule, namely, that of hydrogen, we see that while a hydrogen molecule represents something (electrical charges or waves) in extremely rapid motion, it also represents an extremely stable system. The stability here is dynamic instead of static, but of a very high order nevertheless—so high in fact that hitherto no matter how much energy has been applied to it this stability has not yet been upset. While we do not know very much about the true structure of the hydrogen atom or indeed the atom of any other element, it would be reasonable to expect that since very nearly everything else in the earth whether chemical or mechanical has reached a state of equilibrium, the atom, which is the foundation of the whole structure of matter, must have also reached a high degree of stability or equilibrium. This would lead one to believe that as little energy can be produced by the breakdown of an atom in any of the common elements encountered on the earth as there can be produced energy by trying to burn, for example, carbon dioxide. True, there is good reason to believe that the enormous amount of heat given out by the sun is the result of the breakdown of atoms, but there we are dealing not with the common elements, such as hydrogen, carbon, nitrogen, and the like, but with an entirely different group, namely, radioactive elements, which are apparently elements that have not yet reached the stage of interatomic stability, and of which hitherto only insignificant traces have been found on the earth. If this is so, then there is only very little hope for obtaining energy from the breakdown of any of the atoms known to occur in quantity on the earth.

When we come to the question of fuelless motors and the like, it will be well to bear in mind that the only way known to us by which industrially applicable power can be generated is to find in nature something which represents chemically or mechanically a lack of balance and to carry out the reaction which will create that balance, be it by piling up water by means of a dam and letting it fall to a much lower level, or by bringing up from under the ground a fuel. There is no way of obtaining energy without some such effort, because all generation of energy represents either a mechanical or chemical reaction tending to bring things of the earth into a state of balance, and had the elements of this reaction been lying side by side ready for combination, they would have combined in the 100,000,000 years that our planet has been in business.

Some Economic Factors in Power-Station Design

By H. BOYD BRYDON,[1] CHICAGO, ILL.

After a discussion of capacity factors and average loads of steam turbines over a sixteen-year life period, the author examines the costs of seven 60,000-kw. unit plants. Of these, one is to operate with steam at 400 lb. pressure, three with steam at 600 lb., and three with steam at 1200 lb., there being different reheating arrangements provided in the 600-lb. and 1200-lb. plants. Preliminary layouts of the 400-lb., 600-lb., and 1200-lb. plants are shown. It is concluded that the adoption of the 400-lb. plant is preferable on the score of simplicity, ease of operation, and cost. Should conditions ever arise under which the use of a pressure of 1200 or 1500 lb. may become attractive, the proposed pressure will fit in nicely. The 600-lb. plant will not.

THE past few years have afforded repeated instances of the tremendous efforts by those of us charged with the design of power stations to effect reductions in heat consumption. With the growth of our electric systems larger and larger power houses have been built, larger and larger units have been developed, and higher and higher pressures and temperatures have been employed.

Superheaters, economizers, air preheating, the regenerative steam cycle using two, three, and even four stages of steam extraction, reheat of the steam once and twice in its passage through the turbine, all have contributed.

Boilers have been worked to higher and higher capacities, and the consequent destruction of furnace linings has led to air-cooled and then to water-cooled walls.

All these things have helped to reduce the heat required to generate a kilowatt-hour. Pointings with pride and gnashings of teeth have followed the publication of successive records of heat economies from one station after another. But to what extent have these things really been justified from an economic standpoint?

Given sufficient money, it is not difficult to reduce heat consumption. The question is, Will it pay—in dollars? Has not too much attention been paid to the thermodynamic side and too little to the dividend side of power-house design? Are not the dollars spent for capital charges increasing faster than the dollars saved by reduced coal consumption?

By setting high enough the capacity factor at which a proposed plant will operate, justification for increased expenditure to reduce heat consumption may easily be had. It is simply a question of getting the answer first.

But is there not a tendency to overestimate this capacity factor? Is adequate consideration given, for instance, to the effect on the proposed plant of load increase as the years go on? Can we assert with any degree of confidence that we are reaching the saturation point in electric-energy consumption? For if not, the effective life of a new plant may prove much less than that assumed by its designers as justifying refinements of equipment to reduce coal consumption.

The current annual report of the Commonwealth Edison Company remarks that the increase in output for 1927 over 1926 was approximately the same as the company's entire output in 1907.

Papers submitted in competition for the Bonbright Award in 1925 show growth in kilowatt-hours generated for the United States as a whole equivalent to about 50 per cent in five years, and for the East North-Central States equivalent to about 63 per cent in five years, and that the installed generating capacity for the United States as a whole increased about 62 per cent in five years.

If these figures mean anything they mean that, except for possible improvement in load factor, our generating capacity must be doubled every eight to ten years. Unless we admit that no further improvement in equipment can be made, that no better solution of our problems can be achieved, it follows that new equipment working within the same pressure and temperature limits will do its work on a smaller heat consumption than the older. It is true that we are approaching the asymptote of heat economy in plants using steam as the working substance, but research is resulting in continual improvement; tomorrow's steam station will be better than today's, and the day of binary-vapor cycles is not yet.

Consider the initial unit in a new power house built to meet the growing needs of a system containing certain power houses. Naturally this new unit, being more economical as regards coal consumption than the units in the older power houses, will be given the cream of the load. But the very giving of the cream of the load to the new unit affects adversely the load factor and output of all the original power houses, with the result that the total operation cost per kilowatt-hour of these power houses is increased.

It is apparent, therefore, from a financial standpoint that consideration only of the fixed charges on the new installation and its operating cost under prescribed conditions cannot afford a complete solution of the problem. The effect of the new unit on the earning capacity of all the units previously installed should also be considered.

For the new installation itself, selection of equipment and operating conditions of pressure temperature, etc., must be governed by the condition that over its effective life the unit should be capable of delivering to the distributing system the greatest quantity of salable energy per dollar of total cost, total cost being of course the sum of the fixed charges and the operating costs for the whole effective life of the equipment.

Three major factors control:

1 Fixed charges
2 Capacity factor
3 Operated-hours factor.

Fixed Charges

Under given conditions of load and operating ability, reduction of operating cost can only be achieved by increase of fixed charges. If the proposed increase in fixed charges is merely equaled by the estimated reduction in operating cost, obviously nothing has been gained. On the contrary, much has probably been lost, for the fixed charges go on whether the plant operates or not. They are certain, whereas the improvement in operating cost resulting therefrom may not occur, due to load or other conditions outside the control of the operating company.

From the date that installation of additional plant capacity is

[1] M.E., Byllesby Engineering and Management Corp. Mem. A.S.M.E.

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decided upon, capital expenditures are made. These increase until the unit has passed its trials, is in successful operating condition, and ready for commercial service as called upon. The total of these expenditures is the sum upon which interest and taxes must be paid whether they are earned or not.

Furthermore, to protect the capital so expended adequate insurance must be applied and the premiums must be paid.

As soon as the unit is placed in commercial operation a fourth charge becomes necessary: a depreciation fund must be set up adequate to return the capital by the time the earning power of the equipment is at an end.

These charges on that portion of the cost of the plant covered by the estimates given in this paper are assumed as follows:

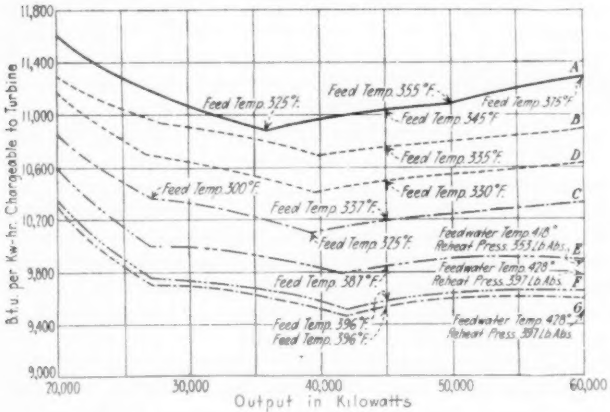

Fig. 1 Thermal Economy of 60,000-Kw. Units

A-A Single-cylinder, 375 lb. gage, 725 deg. fahr., 1.00 in. back pressure, 4-stage extraction.
B-B Tandem-compound unit, 575 lb. gage, 725 deg. fahr., 1.00 in. back pressure, 4-stage extraction.
C-C Tandem-compound unit, 575 lb. gage, 725 deg. fahr., reheat to 725 deg. fahr., 1.00 in. back pressure, 4-stage extraction.
D-D Tandem-compound unit, 575 lb. gage, 725 deg. fahr., steam reheat to 500 deg. fahr., 1.00 in. back pressure, 4-stage extraction.
E-E Cross-compound unit, 1200 lb. gage, 725 deg. fahr., steam reheat once to 550 deg. fahr., 1.00 in. back pressure, 4-stage extraction.
F-F Cross-compound unit, 1200 lb. gage, 725 deg. fahr., steam reheat twice to 550 deg. fahr., 1.00 in. back pressure, 4-stage extraction.
G-G Cross-compound unit, 1200 lb. gage, 725 deg. fahr., boiler reheat to 725 deg. fahr., 1.00 in. back pressure, 4-stage extraction.

interest, 7 per cent; depreciation, 4 per cent; and taxes and insurance, $2^1/_2$ per cent; making a total of $13^1/_2$ per cent.

Effective Life

If a sum representing 4 per cent of the capital expenditure be placed every year at interest at 6 per cent compounded annually, the capital will be returned in 15.72 years. In what follows, therefore, an effective life of 16 years has been assumed.

Capacity Factor

Since these fixed charges are not infrequently greater than the production costs, it is clear that the importance can hardly be overstated of estimating as accurately as possible the degree to which use of the proposed capacity will be made throughout its effective life.

Examination of available data has therefore been made to ascertain the proper capacity factor to use in designing this plan. Such information is available in the various reports of the National Electric Light Association, Association of Edison Illuminating Companies, and others.

From a study of curves plotted from the data embodied in these reports, which curves and a discussion thereof are presented in the complete paper, it is difficult to avoid the conclusion that the capacity factor for an assumed effective life of 16 years cannot be expected to be over 40 per cent.

Operated-Hours Factor

Of course, this capacity factor does not mean that the machine will operate at capacity for 40 per cent of the year and be shut down the rest of the time. Time is consumed in starting, applying load, and removing load. It results that the unit is in operation for a considerably longer time than it is carrying full load, so that the average load carried while in operation is less than full load.

From a study of available data it is evident that the average load on the unit throughout its effective life will probably not exceed 65 per cent of its rated capacity, and there is no justification for assuming an average load in excess of 70 per cent.

Basis of Design

The foregoing summarizes an investigation made to determine the bases upon which a proposed power house at Brunot Island should be designed. As a result, it has been concluded that the following factors shall govern:

1 Effective life of the equipment shall be taken at 16 years
2 Capacity factor used shall be 40 per cent
3 Operating factor used shall be 70 per cent
4 It was further decided to use a standard type of unit with which some experience was available as to its operating characteristics. This led to the adoption tentatively of a 60,000-kw., 80-per cent power factor, single-shaft machine.

From the above bases, it followed that the average annual generated output of the unit over its effective life of 16 years would be about 210,000,000 kw-hr.

From the tentative estimates made for auxiliary power requirements, it was found that the corresponding average annual salable output would be about 200,000,000 kw-hr. for a 400-lb. or 600-lb. plant, and about 195,000,000 kw-hr. for a 1200-lb. plant.

Best Operating Pressure

Thermodynamic economy is limited by conditions of pressure and temperatures available or permissible.

The mean annual river temperature at Brunot Island for the past 12 years has been 55.1 deg. fahr. It is evident that this temperature limits the absolute exhaust pressure to one inch of mercury.

Use of commercially available metal limits the steam temperature to 725 deg. fahr. There remains only the steam pressure that may be substantially varied.

Studies have been made for three operating pressures as measured at the outlet of the boiler superheaters, steam temperature in all cases being 725 deg. fahr. at that point.

In all cases an allowance of 25 lb. is made for the pressure drop in piping, valves, etc., so that the steam pressures at the turbine throttle will be 375, 575, and 1175 lb., respectively.

For the 400-lb. plant the steam cycle is taken as straight regenerative.

For the 600-lb. plant three plans were considered: (*a*) Straight regenerative; (*b*) with steam reheat added to (*a*); and (*c*) with boiler reheat added to (*b*).

For the 1200-lb. plant regenerative feed heating was considered with three methods of reheat: (*a*) One-stage steam reheat; (*b*) two-stage steam reheat; and (*c*) two-stage steam reheat and one-stage boiler reheat.

From information received from the manufacturers, the curves in Fig. 1 were prepared showing the net heat chargeable to the turbine for each of these steam cycles.

From these curves and at an average load of 42,000 kw., being 70 per cent of the rated capacity of the unit, Table 1 gives the net heat consumption chargeable to the turbine itself per

kw-hr. generated. The third column shows the percentage of saving in this net turbine heat for the several higher-pressure plants using the 400-lb. plant as the base:

TABLE 1

Steam conditions	Heat per kw-hr., B.t.u.	Heat saving, per cent
400	10,990	...
600 (*a*)	10,710	1.54
600 (*b*)	10,450	4.93
600 (*c*)	10,140	7.76
1200 (*a*)	9,790	10.90
1200 (*b*)	9,530	13.3
1200 (*c*)	9,475	13.8

It should be noted that these savings are for the turbine only; they do not represent the relative economies of stations operated on the several steam cycles.

The cost of the stations is not even approximately identical, and as the added complication of equipment as pressure is increased necessarily involves higher cost of attendance and maintenance, total operating costs do not vary in anything like the same ratio. Furthermore, as depreciation of equipment of plants of substantially higher pressure than 400 lb. is not known with any degree of accuracy, allowance for depreciation for these plants must be largely guesswork. For simplicity, the charge is made 4 per cent for all cases. It is considered that, if anything, this flat figure probably favors the higher-pressure plants when compared with a 400-lb. plant.

TABLE 2 ESTIMATES ON SEVEN TYPES OF PLANT

	Dollars
400-Lb. Plant	
Building	1,868,000
Mechanical equipment	3,668,000
	5,536,000
Overheads, 20 per cent	1,107,000
	6,643,000
Fixed charges, 13½ per cent	896,800
600-Lb. Plant, Cycle (a)	
Building	1,933,000
Mechanical equipment	3,889,000
	5,822,000
Overheads, 20 per cent	1,164,400
	6,986,400
Fixed charges, 13½ per cent	943,100
600-Lb. Plant, Cycle (b)	
Building	1,933,000
Mechanical equipment	3,911,000
	5,844,000
Overheads, 20 per cent	1,169,000
	7,013,000
Fixed charges, 13½ per cent	946,755
600-Lb. Plant Cycle (c)	
Building	2,001,000
Mechanical equipment	3,977,000
	5,978,000
Overheads, 20 per cent	1,195,600
	7,173,600
Fixed charges, 13½ per cent	968,490
1200-Lb. Plant, Cycle (a)	
Building	2,594,000
Mechanical equipment	5,143,000
	7,737,000
Overheads, 20 per cent	1,547,400
	9,284,400
Fixed charges, 13½ per cent	1,253,340
1200-Lb. Plant, Cycle (b)	
Building	2,594,000
Mechanical equipment	5,183,000
	7,777,000
Overheads, 20 per cent	1,555,400
	9,332,400
Fixed charges, 13½ per cent	1,259,820
1200-Lb. Plant, Cycle (c)	
Building	2,610,000
Mechanical equipment	5,737,000
	8,347,000
Overheads, 20 per cent	1,669,400
	10,016,400
Fixed charges, 13½ per cent	1,352,160

Cost of Plant

The estimates in Table 2 cover buildings adequate for two units, one of which is to be installed at present. The estimates do not include cost of electrical equipment, transmission lines, and similar items. Neither do they include legal expense, cost of land, railroad connections, etc. They are necessarily preliminary. Much investigation and study will be needed before the final designs for the plant can be prepared.

Operating Cost

Several items must be considered in estimating the operating cost of the station. Among these are:

a Cost of power used for auxiliary drive
b Method of auxiliary drive
c Effect of pressure on boiler efficiency.

The object of building the station is, within its capacity, to deliver salable electric energy to the distribution system.

If the station is such as to require that of its product 5 per cent is utilized within itself, the value of the station as a producer of salable energy is reduced by 5 per cent. If, however, the available capacity of but part of the equipment of the station is used, not all of that portion of the cost of the station is chargeable against the auxiliaries.

In this respect must be considered the price at which that part of its product used within itself shall be charged against the station. Several views on this point are presented in the complete paper.

Drive for Auxiliary Equipment

The means adopted for driving the auxiliary equipment of the station must be that which first insures starting the station in event of a system shutdown, and, second, offers the greatest security of continuity of operation. Nothing is more annoying when trouble occurs to a main unit than to have it affect operation of the auxiliaries also.

Steam-driven auxiliaries so far as they can be economically used, being independent of electric trouble and of the main units, are preferable as giving the greatest security in this respect.

To some extent the following methods of auxiliary drive can be used singly or in combination:

1 All-steam drive at station steam pressure and temperature
2 All-electric drive from the station bus bars
3 All-electric drive from auxiliary generators, direct driven by the main turbines
4 All-electric drive from auxiliary turbines driving house generators
5 All-electric drive through motor-generators supplied from distribution system
6 All-steam drive from a self-contained auxiliary station having its own boilers.

Subject to the economic requirements, the first method of drive can be used certainly for 400 lb. and probably for 600 lb. For the 1200-lb. station, the cost of the auxiliary turbines and their piping appears to be prohibitive.

The second method is objectionable because of the high cost of transformers and of switch gear, etc., required to withstand rupturing stresses in event of a short-circuit.

The use of auxiliary generators (3) driven by the main turbine is bad from the operating standpoint because trouble on a

main unit requiring shutting it down would also shut down the auxiliaries, thus aggravating the trouble and lengthening its duration.

The house-turbine system (4) has worked out well for moderate pressures, but for 1200-lb. work would be costly and might involve an undesirable degree of risk to continuity of operation.

Given adequate supply by a number of different routes for the cables, the system (5) of driving the station auxiliaries through motor-generators offers a means of escape from the principal objections to methods Nos. 2 and 3. Its cost would be high, however, as it would have to bear its proportion of the distribution expense of the system.

Probably the safest, though not necessarily the least costly system is that (6) of providing a complete and separate auxiliary station supplying steam to the main-station auxiliaries from its own boilers operating at a pressure permitting the use of moderate-priced turbines for the auxiliary drive. It may be considered a variant of method No. 4.

Time has not permitted a sufficiently complete study of these several schemes. They are mentioned to serve as a basis for discussion. The method or methods selected will depend greatly upon the steam conditions for which the station is constructed.

For the immediate purpose of this paper, the power used by the auxiliaries has been estimated in kilowatt-hours. The energy so consumed has been deducted from the generated output of the main unit to obtain the salable output of the station. The results follow:

	Pressure		
	400 lb.	600 lb.	1200 lb.
Generated output, kw-hr...	210,000,000	210,000,000	210,000,000
Required for auxiliaries, kw-hr....................	9,600,000	10,400,000	15,200,000
Salable output, kw-hr......	200,400,000	199,600,000	194,800,000
Say, kw-hr..............	200,000,000	200,000,000	195,000,000

Effect of Pressure on Boiler Efficiency

As operating pressure is increased, temperature of the saturated steam rises and limits to some extent the possible efficiency obtainable from the boiler because it fixes the lowest temperature at which the gases can leave the boiler. For the pressures considered, the saturated-steam temperatures are: 450 lb. abs., 422 deg. fahr.; 650 lb. abs., 495 deg. fahr.; 1250 lb. abs., 568 deg. fahr.

Assuming a furnace temperature of 2800 deg. fahr. and an air temperature in the boiler room of 70 deg. fahr., the maximum gas cooling is 2730 deg. fahr. It follows that the percentage of the possible cooling of the gases for these different boilers is: for the 400-lb. boiler, 87.2 per cent; for the 600-lb. boiler, 84.5 per cent; for the 1200-lb. boiler, 81.7 per cent.

For the purposes of this paper, the efficiency of the boiler plant has been assumed at 86 per cent for all pressures.

Heat Consumption of Plant

For these preliminary estimates, the assumption is made for all plants that the heat consumption of the station per generated kilowatt-hour will be 5 per cent in excess of the net heat chargeable to the turbine as given in Table 1. This figure for the generated energy is then divided by the station output, and by the above boiler efficiency, to obtain the station heat consumption.

Table 3 shows the estimated average annual coal consumption and cost over the effective life of the unit; a heating value of the coal of 13,000 B.t.u. as fired and an average cost of $2.25 per short ton are assumed.

TABLE 3 ESTIMATED AVERAGE COAL CONSUMPTION AND COST PER YEAR

Plant	Coal consumption, tons	Cost, dollars
400	108,150	242,338
600 (*a*)	105,000	236,250
600 (*b*)	102,900	231,525
600 (*c*)	99,860	224,685
1200 (*a*)	96,390	216,887
1200 (*b*)	93,770	210,982
1200 (*c*)	93,345	210,026

Labor

Operating and maintenance labor has been estimated for the first unit on the basis of 71 men at an average wage of $150 per month. No additional labor has been assumed for the higher-pressure plants.

Operating labor.....................	$128,000
Maintenance labor..................	25,000
Total annual labor cost..........	$153,000

Maintenance and Total Operating Costs

Sufficient experience with 1200-lb. plants is not available for determining a proper maintenance cost. While statements have been made that maintenance expense is not appreciably different from moderate-pressure plants, 1200-lb. plants are so new that these statements cannot be accepted as being sufficiently reliable for use over a 16-year life. The figures in Table 4, summarizing the several estimates, are considered fair and show the total operating costs for the several plants.

TABLE 4 TOTAL OPERATING COSTS

400-Lb. Plant	
Fixed charges....................	$ 896,800
Coal....................	243,338
Labor....................	153,000
Maintenance....................	50,000
	$ 1,343,138
600-Lb. Plant, Cycle (*a*)	
Fixed charges....................	$ 943,100
Coal....................	236,250
Labor....................	153,000
Maintenance....................	60,000
	$ 1,392,350
600-Lb. Plant, Cycle (*b*)	
Fixed charges....................	$ 946,755
Coal....................	231,525
Labor....................	153,000
Maintenance....................	60,000
	$ 1,391,280
600-Lb. Plant, Cycle (*c*)	
Fixed charges....................	$ 968,490
Coal....................	224,685
Labor....................	153,000
Maintenance....................	65,000
	$ 1,411,175
1200-Lb. Plant, Cycle (*a*)	
Fixed charges....................	$ 1,253,340
Coal....................	216,877
Labor....................	153,000
Maintenance....................	80,000
	$ 1,703,217
1200-Lb. Plant, Cycle (*b*)	
Fixed charges....................	$ 1,259,820
Coal....................	210,982
Labor....................	163,000
Maintenance....................	80,000
	$ 1,703,802
1200-Lb. Plant, Cycle (*c*)	
Fixed charges....................	$ 1,352,160
Coal....................	210,026
Labor....................	153,000
Maintenance....................	90,000
	$ 1,805,186

Conclusion

It is considered that the adoption of 400 lb. pressure has been shown to be preferable on the score of simplicity, ease of operation, and cost. Should conditions ever arise under which the use of a pressure of 1200 or 1500 lb. may become attractive, the proposed pressure will fit in nicely. The 600-lb. plant will not

Plate-Steel Rotor for an Electric Generator

By H. G. REIST,[1] SCHENECTADY, N. Y.

This paper explains, in brief, the construction of a 220-ton revolving-field spider for a generator driven by a vertical water wheel. In designing this spider the object was to obtain a construction having the least waste of material, ample strength, the fewest unknown quantities, and one which could be economically produced by existing shop equipment.

THE designers of large electrical units have been giving considerable attention to designs of revolving elements that combine safety, simplicity of manufacture, and ease of shipment and installation. Many designs have embodied cast iron or steel, or combinations of these materials. If the overall dimensions are small enough, the spider and rim are usually made in a single casting. Sometimes the spiders are split so that the parts can be readily applied to the shaft. If the diameter is more than ten or twelve feet, the piece must be

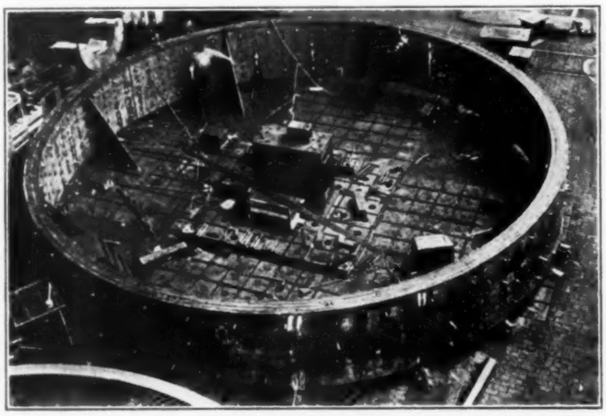

Fig. 1 Assembly of Rotor Rim, Showing Brackets

made in sections for ease in shipment. Large wheels, if cast in two parts, must be made of steel. This construction involves

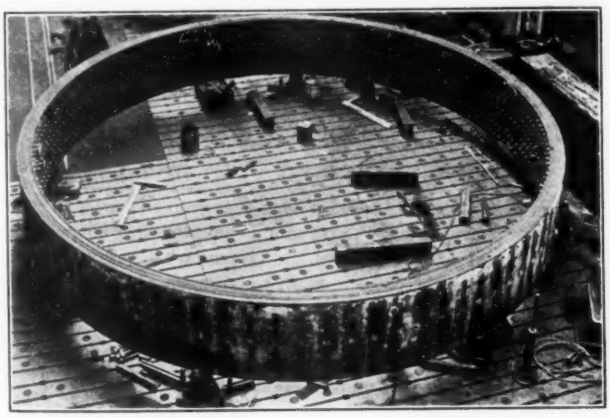

Fig. 2 Rotor Rim Ready to Be Placed on Spider

the use of material that is subject to shrinkage strains and blow holes. When the rim and arms are integral, the rim is subject to bending stresses because the unsupported portion between the arms is deflected by centrifugal forces. Calculations indicate that in ordinary designs the relief of centrifugal stresses, due to support by the arms, is about offset by a bending stress adjacent to the arm. It would seem that a free or floating rim has no higher stress than one that is fastened to the arms. A con-

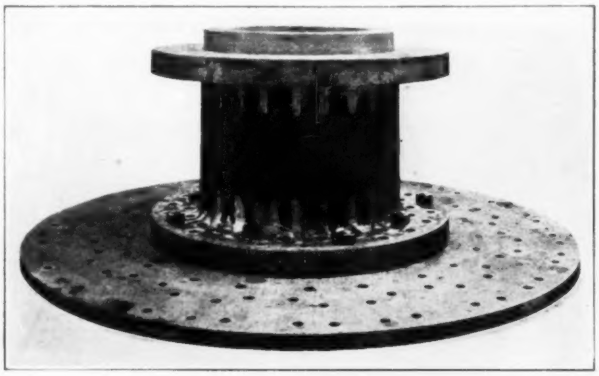

Fig. 3 Rotor Spider Hub

struction that does not require the arms to be fastened to the rim to hold it against centrifugal forces, eliminates local bending stresses, and therefore is preferable.

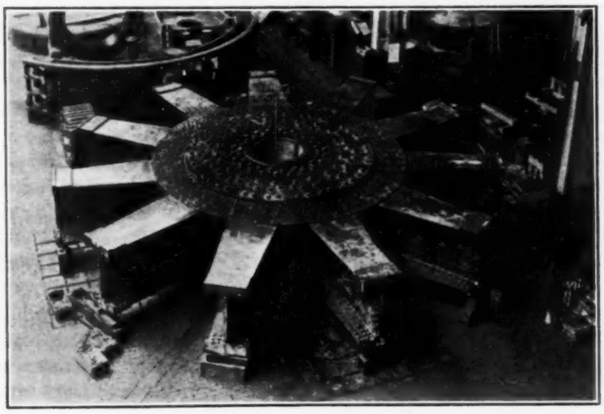

Fig. 4 Assembly of Rotor Spider Hub and Arms

The spider to be described was built for a 40,000-kw. generator having 88 poles and running at 81.8 r.p.m. Four of such spiders are being installed at the hydroelectric plant of the Philadelphia Electric Company, on the Susquehanna River at Conowingo, Md. This spider has a floating rim made of forty-four rolled steel plates. Each plate is the full width of the rim, and extends one-quarter of the way around the circumference. Forty of these plates, constituting ten layers, are $^7/_8$ in. thick. Those in the outer layer are 1 in. thick, to allow stock for truing up. The long plates make it possible to distribute the joints, and a large portion of the cross-section of the rim is utilized for holding it together, the minimum section being much greater than when ordinary methods of fastenings for sections of rims of flywheels are used.

[1] Designing Engineer, Alternating-Current Machinery, General Electric Co. Mem. A.S.M.E.

For presentation at the Spring Meeting, Pittsburgh, Pa., May 14 to 17, 1928, of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y. All papers are subject to revision

This construction makes a rim that is relatively flexible, but this is unimportant when the rim is allowed to float freely.

The plates used in building the rim were bent to shape in rolls used for bending boiler plates. They were of different radii, so that when assembled they fitted closely to each other. They assembled to surprisingly close fits for plates that were not finished. Before the plates were bent, the holes for the bolts for fastening the poles were drilled. These are clearance holes and were used temporarily for drawing the plates together during the assembly.

The rim was assembled around the outer edge of brackets (Fig. 1) bolted to an iron floor. The brackets were carefully spaced so that the diameter of the outer vertical edge was the same as that of the spider arms. Hydraulic jacks were used to pull the plates together with temporary assembling bolts. One of these jacks is shown on this figure. The rim was then drilled

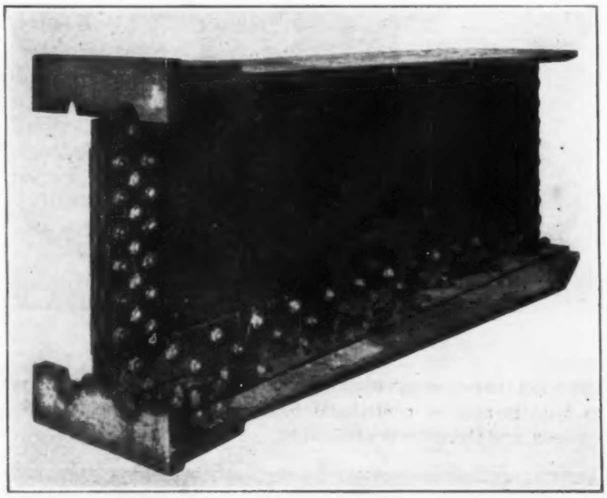

Fig. 5 Rotor Spider Arm

for the bolts which tie the plates together and take the circular shear. These bolts have countersunk heads with square recesses in them. The bolts are turned all over and have a driving fit into the reamed holes. The recess in the head is used to hold the bolt from turning in case the nut should be very tight.

Fig. 2 shows the rim ready to be placed on the spider. The entire structure, with the exception of the hub, is made of steel plates and forgings of materials of known qualities, both physical and chemical, and known to be free from flaws. The hub, which is shown in Fig. 3, partially assembled with a circular plate, is made of cast steel and annealed to relieve shrinkage strains. Rolled end plates, twelve feet in diameter, transmit the torque from the hub to the arms (Fig. 4). A second thinner plate, split, and of larger diameter, distributes the forces over a wider area of the arms. The arms are constructed like a riveted beam, except that bolts are used instead of rivets (Fig. 5). All bolts in the spider center are fitted and have a taper of $^1/_{16}$ in. to the foot. Fig. 6 shows the method of assembling the parts.

The rim is supported and driven by radial dowels. There are four of these dowels driven into the angle plates (Fig. 5) on the top, and four on the bottom of the outer end of each arm. The holes for the dowels are drilled and reamed after the rim is assembled in the spider while it is on the vertical boring mill (Fig. 7). The radial dowels allow the rim to slide freely in a radial direction in case of runaway speed, permitting the rim to expand without producing any bending stresses in it. The radial dowels keep the rim central even if it leaves the spider at overspeed.

Keyways are cut in the end of the arms and two tapered keys are fitted so that when the spider runs at normal speed the keys will be tight and rim and spider will have no clearance between them.

The following figures covering dimensions and weights will

Fig. 6 Method of Assembling Arms and Hub

Fig. 7 Assembly of Hub, Spider, and Rim

give some idea of the size and amount of material used in the building of this spider:

Diameter of spider over rim	29 ft. $8^3/_4$ in.
Depth of rim radially	$9^5/_8$ in.
Width of rim	4 ft. $2^1/_2$ in.
Weight of rim	75 tons
Weight of hub	14 tons
Weight of arms and side plates	61 tons
Weight of poles	70 tons
Weight complete	220 tons

After the rotor was built it was reassembled at the factory to determine whether the parts would come together without any difficulty, and whether they would be true with each other after reassembling, as the rotor was not to be machined after installation. The reassembling was also done to determine whether any special tools might be used to advantage in doing the work at the point of installation. No trouble whatever was found in reassembling the work and no special tools were required.

Foundries here and there are finding that a quicker and more satisfactory method of graphiting molds for castings is to use a welding torch with a low-pressure carbonizing flame, by which the inside of the mold is very quickly and thoroughly smudged, leaving the surface absolutely dry and well lubricated to produce a smooth casting.—*The Engineer*, March 2, 1928, p. 239.

A Water-Level Gage of the Long-Distance Recording Type

By E. B. STROWGER,[1] NIAGARA FALLS, N. Y.

THE importance of having a continuous record of the height of water in remote points of a hydraulic system recorded at some central point has been recognized during the past few years, as is indicated by the development and the marketing of several new types of long-distance recording water-level gages.

In this connection the author wishes to describe a gage of the long-distance recording type which he has been instrumental in putting into operation. The principle involved is not a new one, and furthermore no claim is made for a relatively new application of an old principle. The gage, however, has given such satisfactory service and has answered the needs of a large operating company in such a manner that a brief description seems warranted.

Where a shallow intake exists with the condition of a possible large draw-down, the operator must watch the headwater level closely. Close observation of levels is also necessary in the case of operating a hydro plant with a limited storage in order to generate a maximum number of kilowatt-hours. Fig. 1 shows a plant which has a shallow intake and which, due to a possible

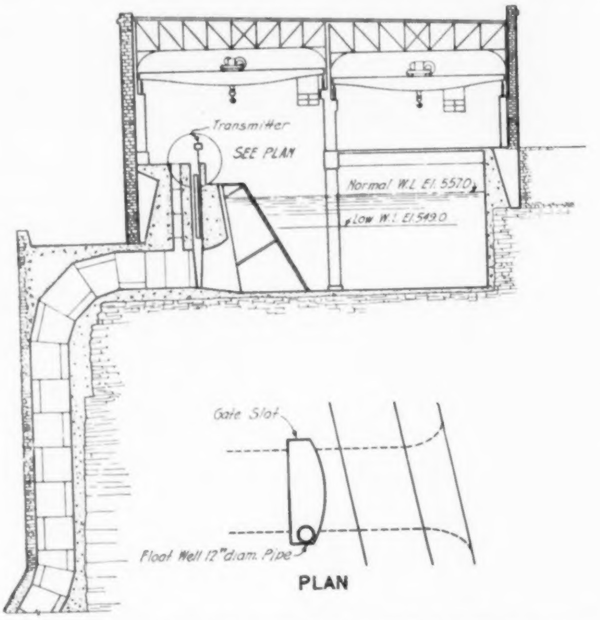

Fig. 1 Shallow Intake with Relatively Large Range in Headwater Level

low river stage existing coincidentally with a heavy load, may experience operating trouble from air taken into the horizontal section of the penstock. This is only one case where the installation of a long-distance recording gage has helped the operator in operating to the best advantage. There are numerous other cases where such a gage would be of great service.

Any water-level gage which records or indicates the water level at a place distant from the point of measurement must have the primary requisites of accuracy and dependability. The usual use of such a gage requires that accuracy should not be sacrificed, and also that the added feature of long-distance transmission of the record should not introduce complications which increase interruptions and failure of records.

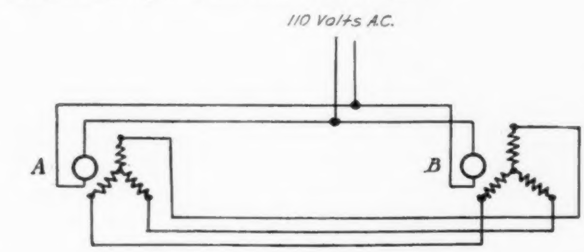

Fig. 2 Selsyn-Motor Diagram

The keeping of gage records may satisfy one or all of several purposes, among which are:

1 Engineering records of stream flow, for hydrograph, duration curves, or mass curves
2 Reports of use of water to state authorities
3 Use by operators for best plant operation and maximum kilowatt-hour output
4 For special purposes, such as records of draft heads on water turbines, records of gross heads on hydroelectric plants, etc.

The gage to be described consists essentially of two Selsyn motors A and B, shown diagrammatically in Fig. 2. The position of the rotor of the transmitter A is controlled by a float or some other means. The follower motor B operates a pen carriage which records on a paper with suitable scaled divisions. The motors are essentially induction motors with wound rotors excited from an alternating-current source. The currents induced in the stator of A have variable intensities in the different windings, depending upon the mutual positions of the rotor and stator. With these induced currents passed through the stator of B, in which the rotor is excited from the same source as that of A, the rotor B will follow the position of rotor A, since it is free to turn except for the small amount of friction due to the bearings and the drag of the pen on the record paper. The follower therefore assumes a position corresponding to the position of the transmitter, whose position in turn is determined by the position of the float. With equilibrium established, no current flows in the secondary or stator circuits. If the follower rotor is restrained, then a torque is set up opposite to the restraining torque. As the two rotors approach a position of equilibrium the torque approaches zero, which tends to make the position of rest lie within the limits of a small angular displacement depending upon the amount of bearing friction, pen friction, etc. This small field of inaction may be made to correspond to a negligible change in water level by the use of the proper number of turns of the rotor per foot change in water stage.

Fig. 3 shows the transmitter with Selsyn motor, gears, phosphor-bronze tape, and 11-in. brass float. The float operates in a 12-in. pipe and has fins as shown to avoid friction and capillary lifting. The counterweighted float operates a drum by means of

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Contributed by the Hydraulic Division for presentation at the Spring Meeting, Pittsburgh, Pa., May 14 to 17, 1928, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. Slightly abridged. All papers are subject to revision.

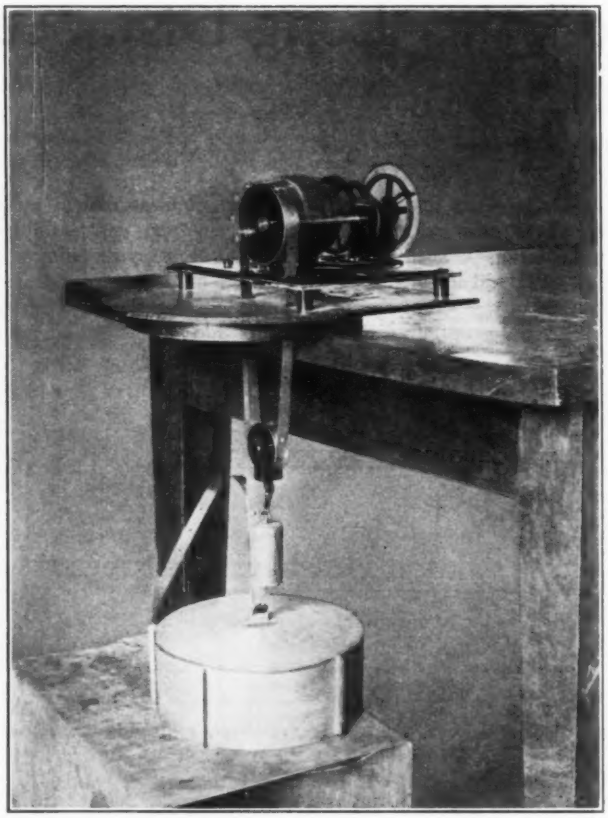

Fig. 3 Transmitter of Water-Level Gage Showing Selsyn Motor, Gears, Tape, and Float

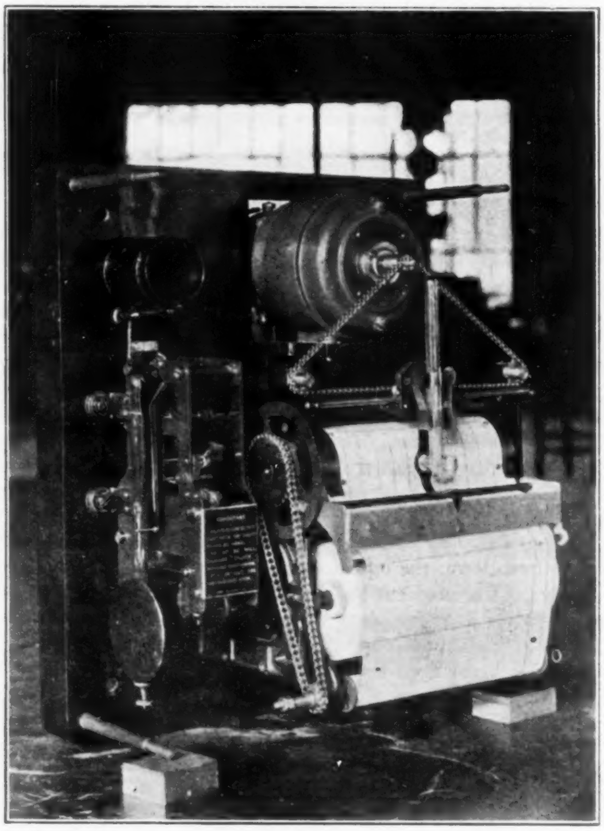

Fig. 4 Recorder of Water-Level Gage Showing Selsyn Motor Used with Westinghouse Recorder

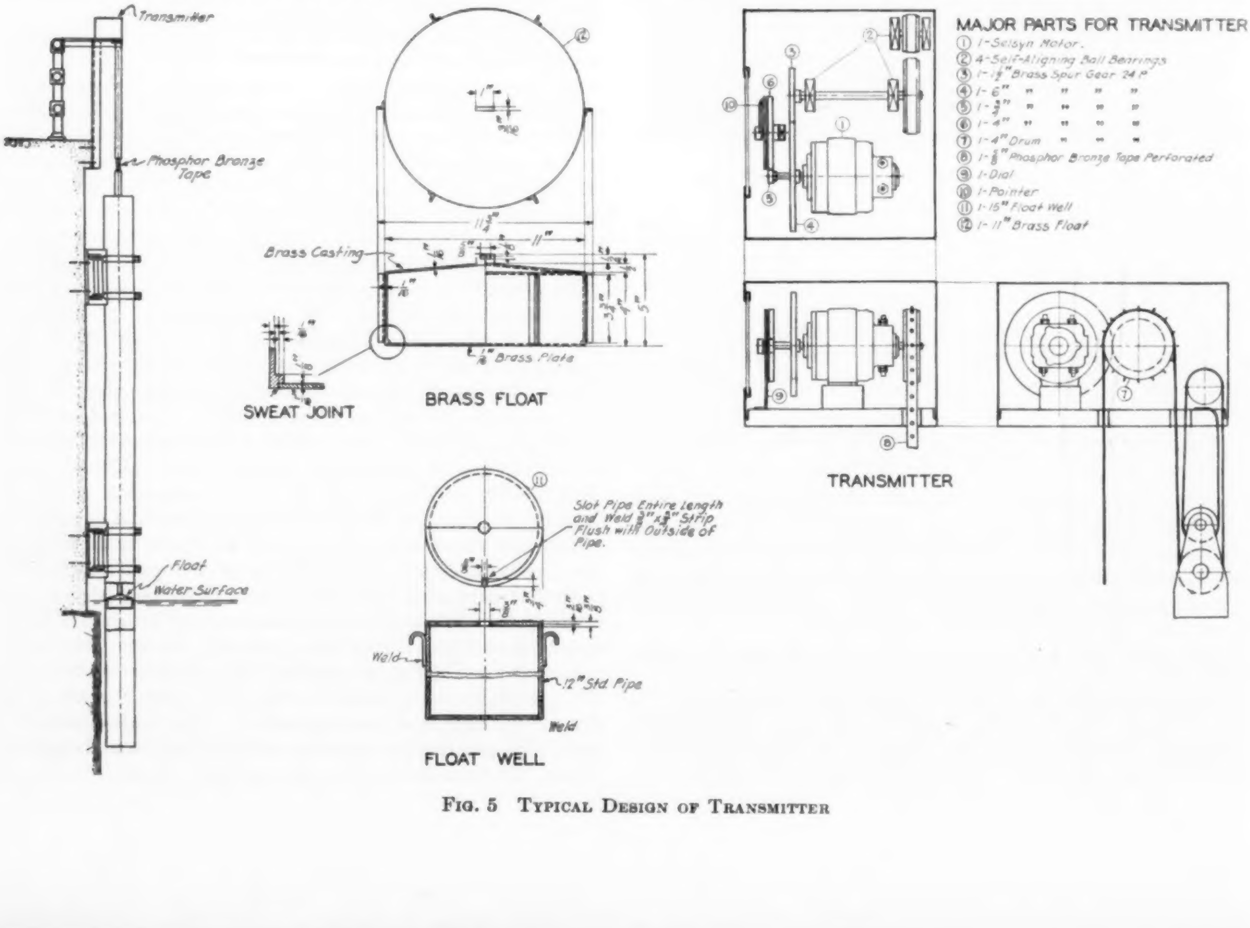

Fig. 5 Typical Design of Transmitter

a perforated phosphor-bronze tape. The drum shaft is geared to the motor shaft and the motor shaft is geared to an indicator which should make less than one revolution for the complete range of the float. It will be noted from the design shown in Fig. 5 that the 12-in. pipe has a $^3/_8$-in. strip welded longitudinally in the pipe and projecting inside. The fins on the float cannot pass the strip, and the float consequently cannot twist the tape.

Fig. 4 shows the recorder with a Selsyn motor used with a Westinghouse, solenoid-operated, graphic, Type M, recording wattmeter case, clock, and recording paper. The *B* or recording-motor shaft carries a six-tooth sprocket which operates the pen carriage by means of a chain and idler sprockets as shown.

The design in Figs. 4 and 5 is for a 20-ft. range in water levels. The rotors make 4.77 turns for a 20-ft. change in stage, or 2.09 ft. change in water level corresponds to one-half revolution of the rotors. If the power supply to the motors fails for a period of time during which time the water level has changed by less than 2 ft., then the gage is self-restoring; otherwise it is not self-restoring. With this design, assuming the "field of inaction" referred to above is 4 deg., then the possible error due to the electrical transmission is $(4/180) \times 2.09 = 0.05$ ft.

For a 10- or 20-ft. range the $5^1/_4$-in. Westinghouse paper is satisfactory, but for a 30-ft. or greater range, a wider paper is preferable.

The details of the paper rewinding mechanism shown in Figs. 4 and 6 are of special design. The rewind roll is driven by the paper drum by means of a chain and suitable sprockets. The driven sprocket wheel is loose on the rewind shaft. A friction clutch is interposed between the driven sprocket wheel and a collar which has a force fit on the same shaft. A light steel spring causes a pressure on the friction surfaces, which pressure may be varied by the adjusting nuts.

Fig. 7 shows three of these gages installed in the control room of The Niagara Falls Power Company. Here the operator has constantly before him a record of the water levels at important points of the hydraulic system and can see not only the effect of station load changes upon the water level, but whether the water level is at a rising or falling stage. The three gages shown are both indicating and recording. The indicator is plainly seen against a calibrated scale upon which a mark may

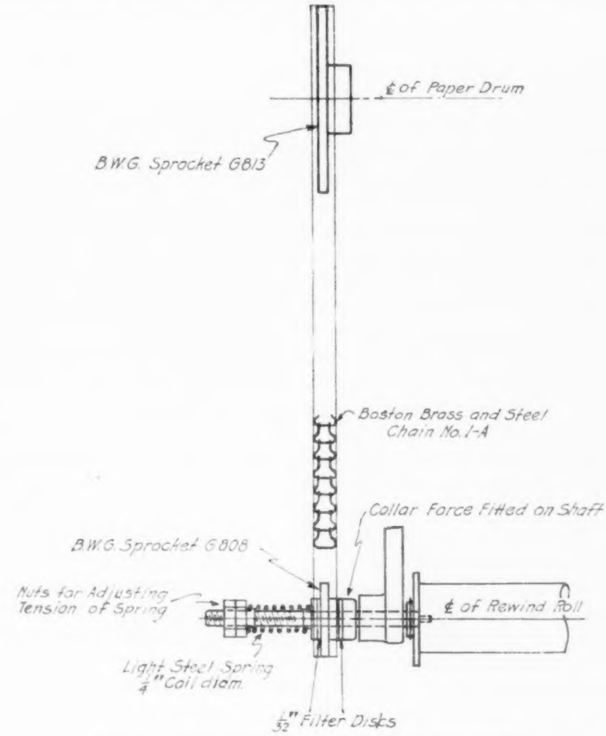

FIG. 6 REWINDING MECHANISM FOR RECORDER

be placed to help the operator in observing the approach of the lower limit. This is shown on the gage on the right of the picture, which gage is operating on the intake shown in Fig. 1.

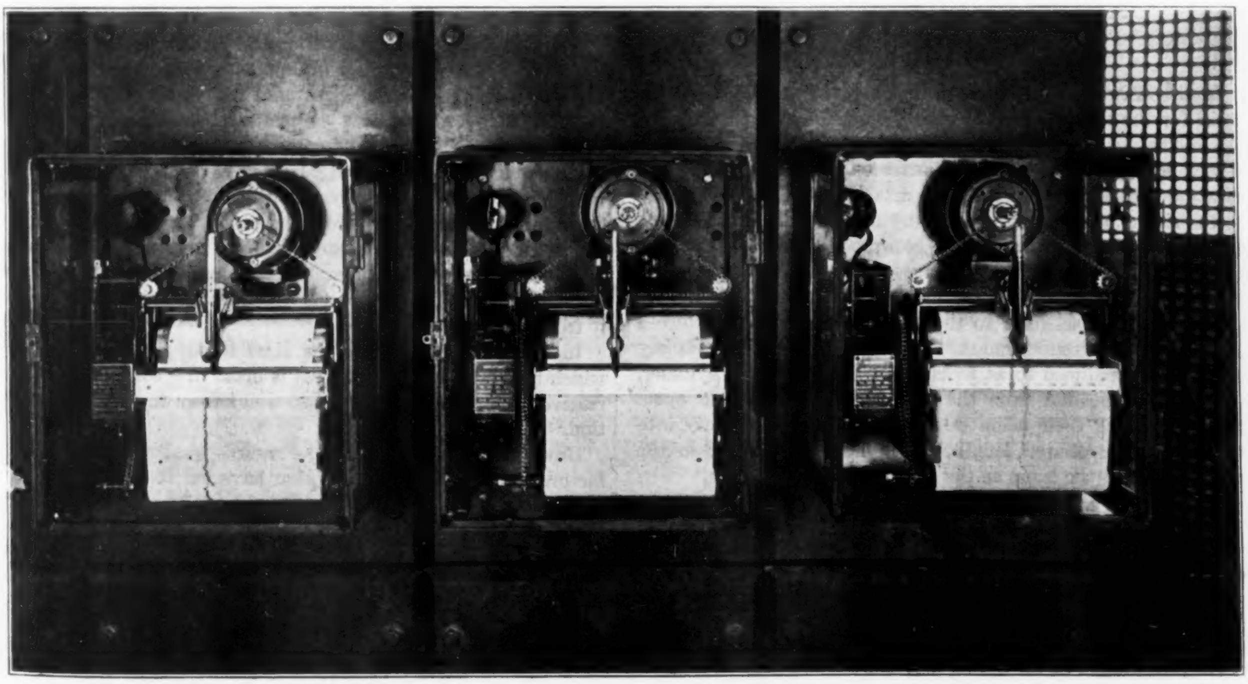

FIG. 7 INSTALLATION OF THREE LONG-DISTANCE RECORDING GAGES IN THE CONTROL ROOM OF THE NIAGARA FALLS POWER COMPANY

Some Recent Improvements in the Manufacture of Flat Glass

By H. K. Hitchcock,[1] Pittsburgh, Pa.

The object of the present paper is to touch on the early methods of making sheet glass; point out the generally accepted methods used; and briefly outline the most recent developments in the industry, giving references to the literature on the subject, so that those interested in it may be able to get in touch with the general line of this development without exhaustive search.

The paper deals first with the primitive, hand-operated ways of producing flat glass by spinning, blowing, and casting; the development of the use of power-driven machinery in casting, blowing, and drawing; and finally with the development of the continuous method of casting from tanks and grinding and polishing, with a brief description of an improved method of casting from pots.

PRACTICALLY up to the beginning of the present century all flat glass used for glazing purposes came under one of the three following categories:

Crown glass, which was made by rapidly whirling a hollow sphere of glass on the end of a "punty" or specially shaped iron rod until it was spun into a disk, from which the sheets were cut.[2]

Window glass, which was made by gathering a ball of glass on the end of a blowpipe, blowing it into a cylinder, and afterward flattening it into sheet form.[3]

Plate glass, in which the glass was rolled out on a metal table, annealed, and afterward ground and polished.

The first of these processes has practically disappeared. In the second one the size and thickness of the glass were limited by the ability of the man to handle the weight of glass involved which resulted in this being a laborious and expensive means of producing a sheet of glass. This process has been almost entirely supplanted by the introduction of machinery in which the glass is drawn either in flat or cylindrical form.

Mechanically Drawn Cylinders

In the drawing of cylinders, a bait made of cast iron like the mold for the top of a bottle, with a blowpipe attached to it, is lowered into a mass of molten glass; the bait being then raised, a neck similar to the neck of a bottle is first formed. The bait slowly begins to rise and the glass attached thereto is expanded to the size of the desired cylinder by means of the introduction of air to the interior through the blowpipe. The bait then continues to rise at a uniform velocity while sufficient air is introduced into the interior of the cylinder to maintain its dimensions. After it has risen to the height necessary to produce a cylinder of the desired length, the bait then rises very rapidly and air is introduced so as to blow off the end of the cylinder, leaving it suspended from the bait with the lower end open. The cylinder is then taken down by special devices, cut into sections of the desired length, and split and flattened in the flattening oven the same as the old hand-blown cylinder.[4]

Drawing Sheet Glass Direct from the Molten Bath

While the drawing of cylinders was a very great advance over the hand method, every one recognized that if it were possible to draw glass in sheet form directly from the molten bath, it would eliminate the troubles involved in the flattening operation and should produce a better article at a lower cost. There are several devices for the drawing of sheet glass direct from the bath that are in use today, the three principal ones being the Fourcault process, the Libby-Owens process, and the Pittsburgh Plate Glass process.

The Fourcault Process. In the Fourcault process the glass is continuously forced up through a slot in a refractory body and the blank so formed is continuously stretched to its desired dimensions in a heated vertical chamber as fast as formed, the tension being applied to the glass sheet by means of rolls which bear on either side of the sheet and elevate it through the "lehr," which consist of a series of vertical chambers having progressively lower temperatures, superimposed one above the other. The glass emerges above the top of this series of chambers annealed, and cooled enough to be cut into sheets of standard sizes.[5]

The Libby-Owens Process. In the Libby-Owens process the sheet is drawn directly from an open bath of molten glass, reheated, and bent over a roller which changes its direction of movement from a vertical to a horizontal plane; it then passes over a continuously moving flattening table and through a lehr in which it is supported on a series of rollers and in which it is annealed and allowed to cool down to the proper temperature for handling. The width of the sheet in the Libby-Owens process is maintained by means of two pairs of knurled rollers, one on each edge of the sheet, which grip the sheet, roll down the edge, and maintain its width and flatness.[6]

The Pittsburgh Plate Glass Process. In the Pittsburgh Plate Glass Company's system of manufacture the sheet is drawn directly from the bath of glass, and its position in the bath is determined by means of a submerged bar, which prevents it from wandering back and forth. Its width is maintained by means of a tension in the edge, which is regulated by means of two hemispherical-shaped pieces which partially surround the edges and prevent them from becoming too cold.[7]

The drawn sheet is elevated through a vertical lehr similar to the one used by the Fourcault process, and the glass is cracked off at the top by heated ribbons which clamp the glass and sever it from the advancing sheet.[8]

In all of these processes the glass to supply the bath from which these sheets are developed is made in a continuous regenerative tank furnace, which is too well known to require description.

However, the requirements as regards quality for the manufacture of glass of this description have led to a very high development in both the efficiency of the tank and the quality of the glass which they produce, and the fact that the glass is entirely handled by machinery has resulted in the production of wider and wider sheets and thicker and thicker glass, so at the

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[1] Consulting Engineer, Pittsburgh Plate Glass Company.

[2] See Rosenhain: "Glass Manufacture" (Van Nostrand, N. Y.), p. 148.

[3] Ibid., p. 159.

[4] This process is fully described and illustrated in a catalog published in 1923 by the Pittsburgh Plate Glass Company, beginning on page 173. This catalog is to be found in most libraries.

For presentation at the Spring Meeting, Pittsburgh, Pa., May 14 to 17, 1928, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

[5] See U.S. Patent to Fourcault, No. 901,800.

[6] See U.S. Patent to Colburn, No. 1,248,809.

[7] See U.S. Patents to Slingluff, Nos. 1,549,513, 1,364,875, and 1,544,947, and U.S. Patent to Koupal, No. 1,598,730.

[8] See U.S. Patent to Slingluff, No. 1,373,533.

present time it is practical to make sheets of almost any desired width and thickness by these drawing methods.

Former Method of Manufacturing Plate Glass

Melting. In the manufacture of plate glass, the third of the processes mentioned, instead of the glass being melted in a continuous tank furnace it is usually melted in pots or specially prepared crucibles, which are situated on the hearth of a regenerative furnace of a special type; the sides of this furnace are full of openings, enabling the pots to be easily removed, and the openings are closed by large clay doors called "tuilles."

In these furnaces the batch, which is more carefully selected than for window glass, is charged into the pots through openings in the doors, thoroughly melted and refined at a temperature of approximately 2600 deg. fahr., after which the furnace and pots are allowed to cool down to a casting temperature of approximately 2200 deg. fahr. The tuilles are then lifted and the pots removed by huge clamps, which until the beginning of the present century were mounted on wheels and operated manually. The pots being withdrawn, they are thoroughly cleaned, clamped into a pair of teeming tongs, and lifted to a height above the casting table sufficient to enable the glass to be poured on its top in front of a roller.

Casting. Previous to 1900 this casting table was situated opposite an oven, the hearth of which consisted of bricks loosely laid in sand which had been carefully dressed when cold so as to present a perfectly flat surface to support the glass, the oven having been heated to a temperature at which the glass would still be more or less plastic. This casting apparatus consisted of a cast-iron roller placed on a cast-iron table mounted on wheels on a track, which enabled it to be brought successively in front of one oven after another.

The cast-iron roller on this table was supported upon two metal strips called "trams," equal to the thickness of the glass desired, and spaced apart a distance equal to the width of the desired plate.

The pot, which was supported for lateral movement across the table in a pair of tongs which would permit of the tilting of the pot, was placed adjacent to one end of the roller and tilted to allow the glass to run out on to the table in front of the roller. At the same time the pot was pushed from one end of the roller to the other in such a manner as to spread the glass as evenly as possible on the table in front of the roller. The roller was then caused to pass over the glass so as to roll it out into a sheet in the same manner in which pie crust is rolled. The roller was then removed and the glass shoved into the preheated kiln. These kilns usually would receive three or four plates of glass, the first being shoved to the back of the kiln and the others placed successively in front of it.

Annealing. When the kiln was filled with these plates of glass, the opening was closed and as nearly hermetically sealed as could be done, the fires turned off, and the kiln and plates allowed to cool to normal temperature, the process requiring three or four days to accomplish. The glass was then withdrawn, trimmed on its edges, and taken to the rough-glass storage, which was at one end of the casting hall adjacent to the grinding shed. This work all being done manually and the surroundings being very hot, the men worked stripped to the waist, and the red glow from the furnace on their steaming bodies presented one of the most picturesque sights known to any industry.

Grinding and Polishing. This rough glass was then cemented to the tops of rotating tables. Carriages having runners mounted thereon, shod with cast-iron shoes, were than placed over the glass and its surface reduced to a plane by the application of abrasives and water between the top of the glass and the bottom of the cast-iron shoes. The glass was then turned over and ground on the second side, after which it was taken to the polishing shop, cemented to a separate table, and polished by means of the application of rouge to rubbing blocks shod with felt.

Improved Plate-Glass Casting and Annealing

About the beginning of the present century the first great improvement in the manufacture of plate glass took place in the substitution of huge traveling power-driven cranes for taking the pots from the furnace and pouring them on the table, the introduction of a continuous lehr for annealing the sheets, and the substitution of rotary polishers and transfer tables in the grinding and polishing operation. This process is admirably described and illustrated in the Pittsburgh Plate Glass Company's catalog of 1923, and has continued to be the process by which most of the plate glass has been made up to the present time.

Changed Demand for Sizes of Plate Glass

Until the advent of the automobile, and especially the closed car, the bulk of the demand for plate glass was for very large sizes such as that used in store fronts, so that all the rough plates of glass were cast in sizes containing 200 sq. ft. or more. After this glass was ground and polished it was carefully inspected and the defects cut out so as to leave the largest plates possible, which left the small glass as a sort of by-product for which the demand was far from equal to the supply; but the coming of the automobile soon changed the character of the sizes in greatest demand, so that it soon became necessary to cut up these large sheets into smaller sheets to supply it. This shift in the market conditions made it possible to start with sheets of much smaller dimensions than before. Consequently new systems of manufacture became possible that would not have been commercially successful in the early days when the demand was almost entirely for large-size sheets.

Plate Glass from Continuous Tanks

The improvements in the continuous-tank construction and the quality of the glass which it produced had been developed to meet the requirements of the various new methods of drawing window glass, so that it was practical to draw glass of sufficient thickness to enable it to be subsequently ground and polished to form plate glass. The trouble, however, with these methods of forming the rough sheet to be subsequently ground and polished was that bubbles or seeds or any defects in the body of the glass in the tank were drawn out into long lines which magnified the defects in the resulting plates so that only a very limited amount of the melt drawn could be used for plate-glass purposes, the remainder having to be sold as window glass. The various manufacturers therefore began to experiment on rolling processes which might be attached to the tank furnaces, which processes, by eliminating the stretching, would leave the bubbles and other defects more inconspicuous than in the drawing method. The result of this experimentation has been that tank furnaces are beginning to be used to some extent in the manufacture of plate glass.

Method of Casting Continuously from Tank

One of the most successful of these processes consists in forcing a stream of molten glass through a refractory slot which gives it the preliminary shape, and then immediately before the glass has the time to chill, passing it between a pair of rollers to give it more accurate dimensions, stretching it slightly to make it flat, and then passing it through a continuous lehr wherein it is supported on a series of rollers placed close together so that the resulting sheet is straightened in its path from the hot end to the cold end and annealed and gradually cooled. In this

way a continuous ribbon of glass is made that is hundreds of feet in length and up to ten feet in width.[9]

One would suppose it to be a very simple problem to develop a system of manufacture of this kind inasmuch as it seems a direct and simple thing to take the product of the tank, which has reached a high state of development, run it through a pair of rollers (a process which is commonly used in many metallurgical operations), and then anneal it, all of which operations are well known. However, to get a product good enough to be used for polished plate glass is a very difficult operation, indeed, and has required no end of research and experimentation, to say nothing of the expenditure of vast sums of money.

To describe the highly organized mechanism which produces this result would transcend the legitimate limits of a paper of this kind. The author will therefore briefly outline the various steps in the process, referring wherever possible to patents which describe in detail some of the various devices which have been suggested to meet the difficulties involved.

Batch Handling

The materials for the batch consisting of sand, lime, soda ash, salt cake, arsenic, and charcoal, are all brought in cars to the batch house, where they are dumped, dried, and elevated into large storage bins. From the bottom of these bins the various materials are drawn off in proper proportions, mixed in a rotary mixer which is mounted on a car to enable it to pass in succession under the various bins, and after mixing the batch is deposited in the hopper of an elevator and conveyor system which ultimately deposits it in measured and timed quantities into the end of a large continuous regenerative glass tank.

Forming the Sheet

There the glass is melted, refined, and discharged through a slot to a pair of water-cooled rollers where it is given accurate dimensions, and from which it passes into a continuous roller lehr, the peripheral speed of the rollers of which is slightly greater than that of the rollers which define the sheet. This difference in speed is controlled so that the operator can take the glass away from the defining rollers at a speed just sufficiently greater than the speed at which it is formed so as to straighten out any wrinkles which may result in the forming operation. Rollers for defining this sheet have to be approximately of a uniform temperature from end to end in order to give the best results. To accomplish this has required no end of experiment.[9] The most satisfactory rollers for this purpose are described in a U.S. patent issued to Hitchcock (No. 1,657,212).

The problem of expansion in a lehr long enough to handle the output of large tank furnaces constitutes a serious problem and has been met by cutting the lehr up into a series of sections with elastic connections between them, and driving them by means of a long shaft running from end to end of the lehr, each element in the lehr having a separate driving mechanism taking off from the shaft.

The controlling of the temperature, and the elimination of the strain in the glass in a long ribbon of this kind are also serious problems and require very accurate temperature control. This is accomplished by means of a series of thermocouples placed in the various sections of the lehrs which accurately record the temperature at a central point, and having a sufficient number of independent heating units to correct the temperature wherever necessary.

Testing for Annealing

At the one end of the lehr where the sheet emerges from the tunnel, is placed a large polarizer which produces a sheet of polarized light through the glass as it travels along. On one side on a swinging arm is a Nicol prism, which enables the operators to study carefully the strain in the glass by analyzing the polarized light passing through it.

Inspecting the Sheet

The sheet then passes into a dark room which is provided with a unique system of lighting, the light all being projected through the edge of the sheet on either side. This light impinges on all the defects in the glass and magnifies them so they are easily seen by a person walking on the glass. In this dark room an operator marks the defects that need to be cut out and also indicates the points at which the sheet should be cut in order to eliminate them.

Cutting Out Defects

After the glass passes out of this dark room it comes on to a cutting table where it is cut to the desired length and then transferred to an elevated platform which is adjacent to the end of the train of tables which carry the glass through the subsequent grinding and polishing operation.

In a continuous system of casting it is imperative that there shall be no interruption in the movement of the glass once it is started, so there are provided two motors to drive the casting rolls and the lehr mechanism, either one of which will be able to do the work should anything happen to the other, and an ample storage battery automatically cuts in should the power go off.

Continuous Grinding and Polishing

Starting with a ribbon of glass which has given dimensions, it is a simple matter to cut it into standard lengths so that instead of having a big variety of sizes which it is necessary to grind and polish, practically all of the glass which goes into the grinding and polishing departments is of a standard size. It is possible to lay a product of this kind on a continuous grinding table and pass it successively under a series of motor-driven grinders, where the glass is first ground plane and given a fine smooth, and then polished. The grinding and polishing departments are situated in a long building located between two continuous casting units so that the glass can be taken directly from the ends of the lehrs and delivered to the grinding tables. This grinding and polishing apparatus consists of four parallel tracks running from one end of the building to the other, two being used to support the tables during the grinding and polishing operation, and the other two for the return of the tables from the polishing end to the grinders.[10]

Laying the Rough Glass

The rough glass being delivered at a central place, which is at one side of the place where it is laid at the beginning of the grinding, a simple mechanical device takes the glass directly from the end of the lehr and deposits it on to the tables on which it is to be ground.

The Grinder Tables

These are cast-iron tables mounted on wheels provided with Timken roller bearings. The bearings are placed in thimbles which are eccentric to the holes in the frame of the tables, so that by rotating them it is possible to adjust the tables accurately for height.[11] These tables are provided on each end with flat

[9] See U.S. Patent to Hitchcock No. 1,538,327, and U.S. Patents to Gelstharp, Nos. 1,532,134, 1,560,077, 1,590,820, 1,560,078, 1,560,-079, and 1,615,834.

[10] This general scheme is described in U.S. Patents to Fox, Nos. 1,492,974 and 1,554,804, U.S. Patent to Fox, et al., No. 1,610,366, and U.S. Patent to Evans, No. 1,657,206.

[11] See U.S. Patent to Evans, No. 1,583,785.

dowels so placed that when two tables are shoved together, their top surfaces register perfectly, and by the adjustment in the wheels it is possible to make the cars both bear equally upon the track upon which the tables are mounted. The track is laid perfectly level and secured to steel framework, so that as the tables start from one end of the grinding shop to the other end of the polishing shed they move in a straight line with their tops always in the same plane. They are driven by a large spur gear which meshes into a rack secured to each table, so that they are pushed from the laying yard to the stripping yard at the other end of the polishing shop.

The tables are also held together by means of special couplings consisting of latches which are easily brought in contact, and then they are clamped together by the movement of a lever which is eccentrically mounted in the eye of the latch, so that when the lever is pulled it clamps the tables securely together.[12]

The Grinder Runners

Spaced apart over the tops of the tables which carry the glass as it passes through these processes are a series of resiliently supported and detachably mounted grinder units driven by motors, each grinder runner being mounted to permit a limited universal movement,[13] and fed with sand or other abrasive, each successive runner receiving a grade of abrasive finer than the one preceding. This sand is fed through the center of the runner and is distributed by means of cast-iron blocks attached to the runner bottom. It is necessary that the runner iron should be so distributed on the bottom of this runner as to equally distribute the sand over the glass and at the same time present to each square inch of the glass the same amount of grinding effect in order that the resulting surface of the glass shall be perfectly plane.

The successful handling of the abrasive for this operation requires a complicated apparatus which will be dealt with later.

The Polisher Runners

After the glass has been thoroughly jointed and the plaster given time enough to harden, the train of tables passes under a series of polishers which are substantially the same as the grinders except that the runners which apply the rouge to the glass consist of a series of spiders carrying loosely mounted pins which are free to move up and down. On the bottom of these pins are a series of cast-iron blocks with felt attached to their lower faces.

Rouge in various qualities is fed to the felted runners in quantities suitable to the work required of it. It is quite imperative that the amount of rouge fed to the runner should not be sufficient to burn the glass before it has been thoroughly polished, and also quite necessary that the block should be kept soft at all times to prevent sleeking the glass, which will occur if the proper composition of rouge is not fed to the blocks.

Transferring of Tables

After the glass has passed under a series of these runners it becomes polished and passes out into the stripping yard where the tables are disconnected from the train by a small electric locomotive, drawn on to the transfer table,[14] and transferred to another track on which they are shoved and where an endless chain picks them up and returns them to the laying yard at the other end of the grinding and polishing shop.

The Turnover Yard

The glass is here turned over by a machine identical with the one which originally laid the glass on the first side. This machine consists of a traveling crane on which is a vacuum-cup frame mounted on a trolley and provided with a hoist. On the lower side of this frame are a series of vacuum cups which, when allowed to come down in contact with the upper surface of the glass and the air is exhausted, fasten themselves to the sheet securely. The frame is then lifted to remove it from the table, and the sheet of glass is transferred into a U-shaped frame while it lies in a horizontal direction. The vacuum cups are then released and the U-frame rotated through an angle of 180 deg., and the vacuum frame is again dropped on to the top side of the glass which was originally the bottom. It is then taken out of the U-frame and carried over to the waiting tables, to which it is cemented as was done in the first place.[15]

Stripping, Dipping, and Cleaning

After the glass has been laid on the second side and the plaster allowed to set, it is run through a second series of grinders and polishers and comes out at the further end of the second group of polishing machines a finished product. Here the glass is lifted from the table by means of a vacuum frame and piled on racks, which when full are picked up by cranes and lowered to the floor below and placed in a tank of weak muriatic acid and left there long enough to change the sulphate of lime to muriate of lime, which latter is soluble in water and enables the glass to be more easily washed and cleaned.

The glass having been taken out of the acid tanks, it is rinsed in clean water and then transferred to other cars which carry it to the cutting room where it is inspected, sorted, and cut to size.

This process goes on continuously for twenty-four hours, except that the warehouse where the glass is inspected and cut is run on an eight-hour basis, the glass accumulating during the night being stored on cars.

Grading and Handling the Abrasive

Returning to the grinding and smoothing operation—which is the prime essential to the success of the whole process—it is necessary in a plant of this kind to feed to the various grinders large quantities of abrasive per minute in various sizes. In order to accomplish this a device has been perfected which takes the rough sand, pumps it into a large inverted cone where it is separated into grades, and these grades are automatically fed from the cone to the grinders, each grade being taken from a different position in the cone. The sand which feeds the first grinders being the coarsest, is taken from the inverted cone at its apex; the subsequent grinders are fed with grades of sand taken from positions higher up in the cone, that is, further away from the apex, each grade of sand being finer than the one preceding due to the fact that the upward velocity in the cone decreases as the area increases and the various volumes of sand and water are removed and fed to the grinders.[16]

The flow of coarse sand to the system is regulated by automatic means of measuring the density of the grinding sand in the apex of the cone. Also automatic means are provided for regulating the velocity of the pumps to insure a constant overflow from the top of the cone. A description of this device would require more space than could be devoted to it in a paper of this kind.

The mechanism which drives the train of grinding tables is also provided with two motors connected through ratchets, so that should anything happen to one of the motors the other will continue to drive the system; these motors are so connected through relays that if the power goes off which supplies them,

[12] See U.S. Patent to Fox, et al., No. 1,610,366.

[13] See U.S. Patent to Soderberg, No. 1,580,175.

[14] See U.S. Patents to Evans, Nos. 1,577,457, 1,596,604, and 1,598,-763.

[15] See U.S. Patent to Heichert, No. 1,519,256.

[16] See U.S. Patents to Hitchcock, Nos. 1,596,658, and No. 1,629,-502, and to Soderberg, No. 1,556,730.

all of the grinding and polishing elements are automatically raised up out of contact with the glass.

Relays placed in the power circuits of each of the grinders and polishers automatically raise their respective runners whenever their motors cease to function from any cause whatsoever.

Casting Pots Between Rolls

The use of a tank furnace for the making of glass of the very highest grade presents certain difficulties. When the tank is new and the blocks of which it is built are in perfect condition, the quality of all of the glass produced in it is apt to be satisfactory if other conditions are what they should be; but the amount of glass of satisfactory quality becomes less and less as the blocks wear away, entailing a very large shrinkage and resulting in higher and higher cost, until it becomes necessary to put out the tank and rebuild it.

The making of glass in pots is not open to this objection, but in casting it on a table as was done in the old process the mechanical qualities of the sheet are not nearly as good as where the glass is rolled between two rollers. A device for rolling flat glass in very long sheets has therefore been developed which combines the advantages of a pot furnace for making glass of high quality with the advantages of the continuous rolling process in producing a sheet of uniform thickness.

It will be readily understood that if the glass is cast absolutely uniform in thickness it can be cast much thinner than where the thickness varies considerably, so that not only is the cost of the additional metal which goes into the thicker sheet saved, but also the cost of grinding away the superfluous glass.

In order to accomplish this result one of the most successful systems consists of a large hollow roller which is continuously rolling on a pair of shafts which support it from the inside. Above this roller is another roller which is continuously turning and which is spaced a distance from the big roller necessary to get the thickness of glass required.

The glass is melted in pots exactly the same as if to be cast on a table, but is teemed between the large and small roller and rolled at a high velocity, producing a sheet 60 or 70 ft. in length and of the required width and thickness. This sheet is fed into the hot end of a lehr on a series of rollers which have a peripheral speed equal to that of the big roller on which this glass is dumped, but as soon as the sheet is perfectly formed, these rollers, by means of automatic devices, are slowed down to the speed of the roller lehr through which the glass is fed, annealed, and cooled, as in the continuous process.[17] By this method sheets of very accurate dimensions are made, and this has contributed largely to the improvement on the old method. The glass cast in this manner can be ground either on the old rotary grinders and polishers, or it can be ground and polished in a continuous machine like that described in the tank process.

[17] See Reissue of U.S. Patent to Showers, No. 16,755, Showers Patent No. 1,579,666, and U.S. Patent to Hitchcock, No. 1,638,769.

Utilization of the Heat Energy of Oceans

REFERENCE was made in Mechanical Engineering, vol. 49, no. 2, Feb., 1927, p. 174, to the Claude and Boucherot proposal to generate power by employing surface sea water under a very high vacuum, the vacuum being produced by using as cooling water in a condenser sea water from deep levels; the surface water being at an average temperature of 26 deg. cent. (78.8 deg. fahr.) and the subsurface water at, say, 3700 ft. depth having a temperature of 3 to 4 deg. cent. (37.4 to 39.2 deg. fahr.). It is claimed that the surface water will boil in a proper vacuum and that the steam can be used in a low-pressure turbine. Experiments with a DeLaval turbine not built for work under these conditions have proved that the proposal is based on sound energy considerations. Thus far, however, no reliable data are available as to the cost and commercial feasibility of this proposal. It is stated, though, that Claude and Boucherot are building at the Ougreé-Marihaye Steel Works a special 50-kw. unit.

Here water from the River Meuse is pumped in approximately equal quantities into two tanks, the level of which is a little above that of the river and represents the sea level. From these tanks the water goes directly to an installation consisting of a boiler and condenser so arranged that the level of the water in these two installations is approximately 10 m. (32.8 ft.) above the level of the tanks. The water in these tanks is heated by steam so that there is a difference of 20 deg. cent. (36 deg. fahr.) between the two. The water then flows into two other tanks connected with the former and located at the same level, the pipes carrying the water being approximately 50 cm. (say, 20 in.) in diameter. The turbine is located between the boiler and the condenser, and is equipped with the usual auxiliaries. It drives a direct-current generator. It has a single wheel running at 5000 r.p.m., which speed it is expected will eventually be raised to 6000.

If this test proves to be successful it is proposed to start experiments under actual sea conditions. The author next considers certain objections made to the proposal here discussed. One of these deals with the difficulty of extracting from the water the dissolved gases, it being stated that in the conventional central station the energy necessary to do this amounts to from 0.1 to 0.2 per cent of the energy generated by the steam turbine, while in the new scheme the energy consumption for this purpose alone will be three or four times as much as the total power furnished by the turbine, which would obviously make the process impossible of accomplishment.

It is pointed out in this connection that in central stations each kilowatt-hour is produced by steam resulting from a total vaporization of 5 kg. (11 lb.) of water and for each kilowatt-hour only the gases dissolved in those 5 kg. of water have to be taken care of. In the ocean-energy process 50 kg. of steam will be necessary to produce the same kilowatt-hour.

To do this it will be necessary to take care of gases from 12,500 kg. of water or 2500 times as much as in an ordinary central station. Assuming that the extraction of dissolved gases consumes in central stations of today from 0.1 to 0.2 per cent of the energy developed by the turbines, it will be seen that in the ocean-energy type of station the same operation would take from 250 to 500 per cent of the energy produced.

The reply to this is that central-station condensers have to be kept substantially free of accumulations of air, while the ocean-energy-type condensers do not. Furthermore, proper handling of the matter of evaporation will take care of the dissolved gases. Finally water releases only a part of the gases contained, after which the degasification is either retarded or stopped completely. The conclusion is that not more than 20 per cent of the turbine energy will be affected by this question of non-condensible vapors.

An appendix to the paper gives a description of previous schemes similar in principle to the Claude-Boucherot proposal. (A. Boutaric, Professor of the Faculty of Science at the University of Dijon, in *Chaleur et Industrie*, vol. 9, no. 94, Feb., 1928, pp. 55–62, *g*)

Some Common Delusions Concerning Depreciation

By ERNEST F. DuBRUL,[1] CINCINNATI, OHIO

This paper points out the effect of inflation of currency in creating illusions as to depreciation accounting. It shows the fallacy of usual accounting practice that takes into cost a depreciation allowance based on the original cost of fixed assets. It shows the necessity of calibrating the dollar measure of value consumed during each period, to allow for changes in the purchasing power of the dollar.

It shows how the present common practice results in overstatement of real profits by understatement of actual depreciation in some cases, and vice versa in others.

The author shows graphically the difference between dollar accounts that are uncalibrated and those that are calibrated for purchasing power. He uses the depreciation and net profits reported by the U.S. Steel Corporation to illustrate the point.

As THIS paper deals with a strictly business question it is well to start with a statement of a simple but fundamental business principle. Such a statement is in point because it has become common, in certain loose-thinking circles, to deny this fundamental principle. Some business men give the loose-thinkers' fallacy a currency that is detrimental to business as such, and to the interests of society as well. The simple principle is that a business is organized for the purpose of making a profit—that the object and end of business is profit.

The loose thinkers say that the object or end of business is service to society, and that profit to the owners is incidental. Clear thinkers realize that unless a business renders society a service for which society is willing to pay, that business will not make a profit. They realize that service is the means whereby business gains its end, its object; which is profit. The loose thinkers merely confuse the end with means.

It is the social as well as the personal duty of management to earn profits, true profits and even big profits—by fair means. It is also the duty of management to know what a true profit is, and neither to deceive nor be deceived by bad, or erroneous, figuring. Any person with even half a grain of economic sense knows that unless a business does make a profit, it cannot long continue to render service. Unless a business attains its profit end, it cannot long continue to employ the service means whereby the end is to be attained.

We all know that society has so far found no better way of getting its necessities, comforts, and luxuries than to have these supplied in the ordinary course of business. Therefore there is nothing inherently dishonorable or discreditable in making profit as so many loose thinkers insinuate and charge. And it is neither honest nor wise for business men to encourage people to think and act as though profit making by fair methods is something to be frowned upon and suppressed. Yet we find many business men who object to another man's price on the sole ground that it gives him a large profit. We find salesmen apologetically arguing that their company's profit is really not great, as though mere greatness of a fairly earned profit were something to be ashamed of.

Economic Justification of Profits

The machine-shop division of the business world would be much better off if more executives would strive for large profits by fair methods and would be proud of the fact, instead of being apologetic. This inferiority complex concerning profit seems to be particularly strong among men engaged in the making of all kinds of production equipment. Yet no other class contributes more to the advancement of the world's material comforts. On that score they should collect a handsomely large profit reward for their efforts. The country gratefully gives them patents on their new and useful inventions. By that policy the country in effect invites the owner of a valid patent to use every fair business device possible to collect as large a reward as his device is economically worth to society.

The mechanical industries have done wonders in bringing down direct costs of other industries, but they have not made very large profits because they have not been good price makers. Were they as good at making profits as they are at making machines, the world would gain still more, because the larger profits would permit and encourage development of even better machines of all sorts than we now have. The mechanical industries are noted among credit men for their high percentage of failures both in number and amount of liabilities. That fact is a sad reflection on the business judgment of mechanical men.

Another sad economic fact for manufacturing plants in general and for machine shops in particular is that the tax laws and regulations often compel overstatement of really small taxable incomes. Yet even these overstated incomes show up smaller than those of financial concerns, whose profits are much more truly reflected in the accounts kept as prescribed by the law. Therefore the fictitiously overstated incomes of these industries do not equal the actual incomes of some other simpler businesses. The overstatement of reported income arises in the accounting treatment the law and regulations provide concerning depreciation.

Depreciation is concerned with fixed assets—buildings, machinery, and production facilities generally, which form a large proportion of a machine shop's capital. Therefore the economic errors made and the delusions entertained by legislators and accountants concerning depreciation should naturally be of great interest to men engaged in operating machine shops.

Accountants accept the principle that a business has not made a profit unless it has gotten a surplus over all costs, both hidden and obvious. But the vast majority of accountants persist in and insist on, making up a lot of cost figures that do not tell the economic truth. They then contend mightily that when these figures are deducted from the sales, the remainder is profit, And Congress believes them and taxes it as such. Worse than that, the executives of machine shops also believe the accountants, and base a price policy on their accountants' erroneous cost figures.

Too few machine-shop executives know enough about accounting and what accounting should do for them in guiding their business. They do not know what a good accountant can do for them; they are not inclined to pay money enough to induce a good accountant to work for them. So it is no great wonder that the failure rate in the machinery line is decidedly above the average rate for all industries.

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The executive should get a cost sheet that shows him whether the price at which the goods were sold has really produced a true profit. His cost sheet should give him a basis of facts on which he can safely build a sound pricing policy. If it does not do these two things it merely misleads him on these two points. The actual facts of cost exist quite independently of either the accountant or his figures. The cost accountant's job is to record facts. Whether he records them well or badly, or whether he even records them at all, does not change facts.

The executive who gets the best, the truest statement of facts is in the best position to formulate sound price policies which will recover all costs in price and produce the best possible profit. Whether he then takes advantage of this actual knowledge is quite another matter. If he goes by a cost sheet that is erroneously low, he is almost certain to make prices on his goods that are too low for real profit to his stockholders. Then his error is bound to affect the prices of his competitors to some extent, no matter how well they may know the actual cost facts.

Practice of Many Accountants Based on False Assumptions

The trouble is that most of our accountant friends are suffering from an economic delusion that makes them base their practice on a false assumption. They know that at a given date a certain number of dollars was spent for a certain quantity of assets bought by the business whose facts they are recording. They record this fact of the spending of these dollars, and there is no doubt that it was a fact. There is no doubt that at the time the money was spent that number of dollars measured the value of the asset. But from that point they proceed on the false assumption that the same dollar record can always be taken as a true measure of the values used up in production, which ought to be shown in the cost of the goods produced by the plant.

Unfortunately for this theory, the dollar has a very puzzling way of changing in purchasing power, and sometimes this change is very rapid. Suppose one bought a ton of pig iron in 1896, when the dollar had the greatest purchasing power known by most of the people now on earth. He could have gotten it at about $6 per ton. Suppose he bought another ton of the same kind of iron in 1920 when prices were about $48 per ton, largely because the general purchasing power of the dollar was the lowest known by most of us alive. Suppose he kept both lots until January, 1928, when iron was selling around $19 a ton.

He could not make any more goods of the same kind out of one lot of iron than out of the other. One had no more and no less utility than the other, but they had a different price due to the change in purchasing power of the dollars they had cost him. Their original prices no longer measured the value of either lot of iron in January, 1928. At that time one lot had a higher value than its cost, the other had a lower value, and both had the value of 1928 regardless of their cost. Their actual value was the value at which they could be replaced in 1928. In production they were worth no more or no less than a 1928 ton of the same kind of iron, and if that is entered on a 1928 cost sheet, it will show the actual value of the iron used.

Quite a number of accountants will agree to that. But most of them would take the high cost, 1920 iron at the 1928 price, but would take the 1896 iron at the price of purchase. So according to that method they would show part of the goods made to have a cost of material that was about one-third of the cost in the other part. The accountants calibrate their measure of value in one direction and refuse to allow calibration in the other direction. Engineers would not think much of that kind of calibration.

Accountants are still more illogical, still more deluded in their treatment of the cost of the services given to production by long-lived plant assets, which cost we call "Depreciation." In that case very few accountants will stand for any calibration in either direction of the measure they use for actual consumption of plant. They are like a man who would insist that the inch marks on a rubber tape line were always the same measure of length no matter how far the tape was stretched or relaxed. We certainly should get some variable-length yards by that system. And we certainly get some random-sized costs by following accounting delusions instead of sticking to business facts.

It is a cold physical fact that when physical plant facilities are worn out they must be replaced by others of at least equal productivity, if the plant is to continue to do business on the same scale. It is a cold business fact that unless the concern has collected from its customers more than enough purchasing power to replace these facilities it has not earned a true profit, a true surplus over all costs. It is another cold business fact that an executive should know how much purchasing power he is using up, before he can know if he is producing a surplus or not.

In Measuring Plant Value Used in Production, the Dollar Measure Should Be Calibrated for Change in Purchasing Power

Now, if the dollar were a stable measure of purchasing power, the accountant could express the value of plant used up in the same dollar that expressed its value at the time of acquisition. But it is another cold business fact that the dollar is not a stable measure of value, and that to measure the plant value used in production the dollar measure should be calibrated for change in purchasing power.

Let us take an example that shows the situation clearly. Assume that a concern built a building in 1913 at a cost of $100,000. Assume that in 1920 it built an exact duplicate, and that its cost conformed to price indexes of buildings and was $250,000. Assume again that in 1925 it built a third building, exactly the same, at a cost of $200,000. Assume each building to house identical departments under separate superintendents, making exactly the same product by exactly the same process. Assume that the company keeps separate costs to check the relative efficiency of each superintendent, and pays them a bonus based on their lowering of costs. Assume that all other costs are exactly the same, except only that the accountant is taking 3 per cent per year building depreciation into each cost sheet. So he charges $3000 against the product of building No. 1, $7500 against product of building No. 2, and $6000 against product of building No. 3. Should superintendent No. 1 get the biggest bonus because of lowest costs? Should he get a larger bonus than the superintendent No. 2 running the shop built in 1920? Silly question, isn't it? But according to most accountants and according to tax regulations the cost of production is lowest in the 1913 plant and highest in the 1920 plant.

Of course, the economic fact is that the costs are the same in all three plants because they are all using up the same amount of building service. The accountant is merely using a differently stretched rubber tape to measure the same thing in the different plants. Suppose that these plants were owned by separate corporations. Suppose they have the same other costs, the same output, and the same sales in units and dollars.

See what happens under the income-tax laws. Plant No. 1 would be taxed on a profit $4500 greater than No. 2, and $3000 greater than No. 3. At present replacement cost all need $6000 a year like No. 3 to measure actual value consumption. But plant No. 1 is allowed only $3000, so it must pay $13^1/_2$ per cent tax on the additional $3000 it needs, so that it must actually lose $405 to Uncle Sam before it can be just exactly square with its own plant. That makes its real depreciation cost $6405 against plant No. 3's $6000.

Plant No. 2, to which the law allows $7500 depreciation, only needs $6000 at actual replacement, so it is really allowed to escape the tax on $1500 of actual profit. To be only just as well off, the accountant of company No. 1 would have to conceal $4500 in its depreciation account instead of showing it as profit. But the officers of No. 1 would go to jail if caught at the trick that the law permits No. 2 to work openly. In effect the law makes company No. 2 a present of $202.50. It is just as though it would split with competitor No. 2 the $405 tax it took out of the fictitious profit it compelled No. 1 to show on its books. Company No. 2 has $202.50 more cash than No. 3 and $405 more than No. 1, out of the same business. The depreciation figured on machinery makes it worse, all because of an accounting delusion. From this illustration it is plain that real, economic profit can be quite different from the figures that the accountant gets as profit by the accounting methods prescribed in the tax laws.

But economic laws are inexorable. Even Congress can't repeal them. So whether the executive recognizes economic laws or not, and whether the accountant records them or not, they go on working. The money illusion is a very common one, whose effects are not as fully realized by business executives as they should be if management is to be wise and skilful in the earning of true profits. Therefore in spite of the cost of keeping two sets of records, and in spite of the accountant's disinclination to do so, it is wise in many cases for the executive to insist on having one set that will tell him truths that the ordinary accounts cannot tell him.

Confusion of Cost Accounting and Tax Accounting

At this point some loose thinker must surely wish to rise up to blast the author with the statement that the Government does not allow a concern to take depreciation from replacement cost, but compels him to take it from cost of acquisition. That is another delusion that does not square with facts. The fact is that Government regulations apply only to records used in computing income taxes. The regulations forbid him from taking true depreciation into these accounts. But they do not forbid him from keeping any records that will show him and his stockholders the actual value of their property or the actual profits and losses the business really made, even though these facts are different from the assumptions on which the law taxes his company.

The wise business executive will cut through any false assumptions that obfuscate and distort the actual facts in his own particular case. He will not be terrified by any loose thinker's bugaboo that he has not full liberty to keep and use any records that will enable him to run his business intelligently. He will not allow his accountant to pad the cost sheets he uses to guide his policy as to price or profit. He will therefore not allow depreciation of unnecessary excess plant to be charged to cost of production. Nor will he allow the costs to be understated. Therefore he will insist on having both interest and depreciation costs figured on the replacement value of the production facilities needed in the business.

The wise executive will not permit confusion of cost accounting and tax accounting as so many accountants do in their minds. He will render unto Uncle Sam the things that the law says he shall render, according to the methods of calculation prescribed in the law. But he will also render unto his stockholders a statement of actual facts as to the true value of the property confided to his management, and will not deceive them in the accounts of his stewardship by either overstatement or understatement of values, profits, or losses.

The money illusion is so common that stockholders are very frequently and unintentionally deceived by reports that do not give them true pictures of actual facts of values and earnings. It is indeed a rare corporation that does not use the elastic tape line to measure its values. Therefore the records of large, well-managed concerns may well be analyzed to see the effects of this dollar delusion.

Illustrative Analysis of Depreciation Account of a Large, Well-Managed Corporation

As an illustration of such an analysis let us put under scrutiny the depreciation account of the U.S. Steel Corporation. The author has dealt with this as well as with other accounts of that corporation in a paper read by him on February 23, 1928, before the Cincinnati Chapter of the National Association of Cost Accountants. So on this occasion he will simply comment on

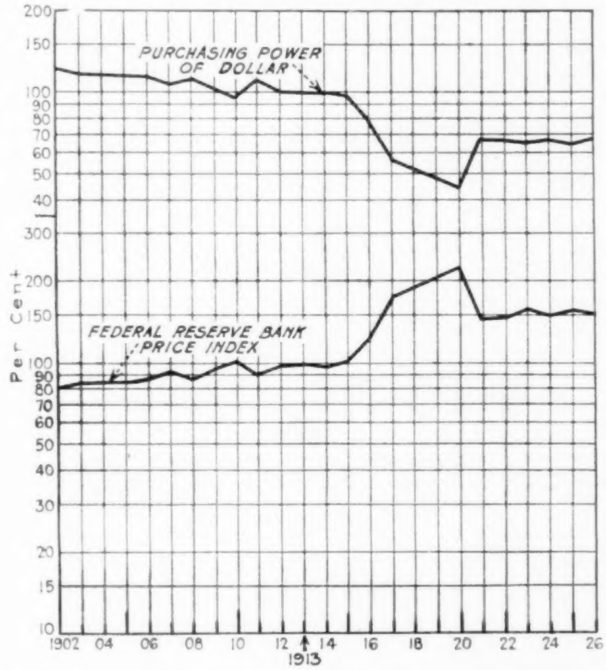

Fig. 1 Chart Showing Price Index and Purchasing Power of the Dollar—Year 1913 Taken as a Base or 100 Per Cent

U.S. Steel's "Depreciation" account as directly in point in this discussion.

Fig. 1 is a semi-logarithmic chart showing the price index used and calculated by the Federal Reserve Bank of New York, using the year 1913 as a base or 100 per cent. This chart begins in 1902 when the average price level was somewhere about 83 per cent of that of 1913. The figures of this study end with the year 1925 when the general price level was about 160 per cent of 1913 prices. The upper line on Fig. 1 shows the purchasing power of a dollar relative to 1913, and the lower line shows the value of commodities relative to the dollar. These two lines are exact mirrors or reciprocals, one of the other.

Fig. 2 shows on the upper line the relative change in the U.S. Steel Corporation's proportion of the total production of steel ingots, year by year, taking its participation in 1913 as 100 per cent. The lower curve on this chart shows the corporation's ingot production in tons, also in percentage of its 1913 production. The obvious conclusion to be drawn from these two curves is that in spite of the corporation's large increase in production, the total production increased much more rapidly so that its relative participation declined as shown on the upper curve of this chart. The author is not presenting here the other charts

he has worked out dealing with the gross receipts, general expenses, wages, taxes, and the net profit available for the stockholder.

Fig. 3 plots the depreciation account in raw dollars on the upper curve. The lower curve shows the depreciation account deflated by dividing the actual amounts taken by the corporation each year by the price index of that year. This reduces the depreciation account to an index of 1913 purchasing power.

The fluctuation in the upper curve of raw dollars of depreciation shows that the amount taken was evidently not calculated on the straight-line method but had some relationship to either tonnage or gross receipts. In the lower curve of deflated depreciation it is evident that the trend of purchasing power actually set aside by the corporation is very slightly upward. As the trend of production goes up decidedly faster, this leads one to wonder whether the corporation is actually allowing full depreciation. Certainly the large production capacity represents more physical capital in the shape of larger, more complex, and more automatic machinery, larger furnaces, cranes, and all other items that go to make up its plants. Even at the same price level, all these more complicated pieces of equipment would be more costly than the simpler equipment and plant structures of 1902.

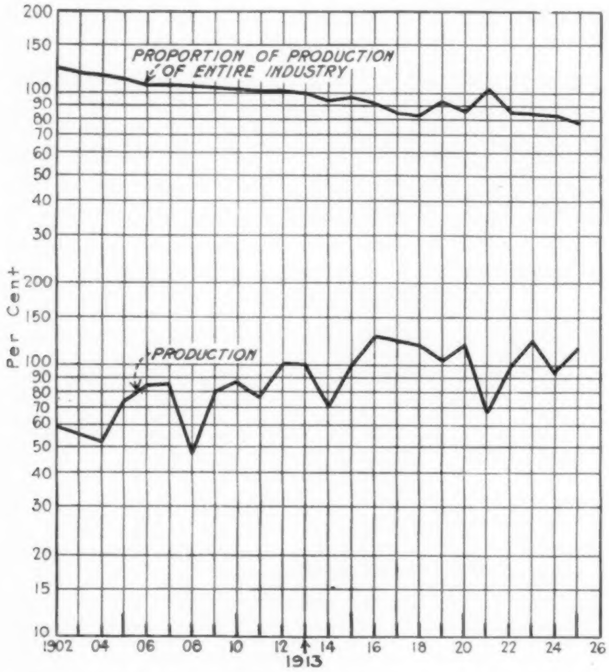

Fig. 2 Chart Showing Relative Change in the U.S. Steel Corporation's Proportion of the Total Production of Steel Ingots, and Its Ingot Production in Tons—Year 1913 Taken as a Base or 100 Per Cent

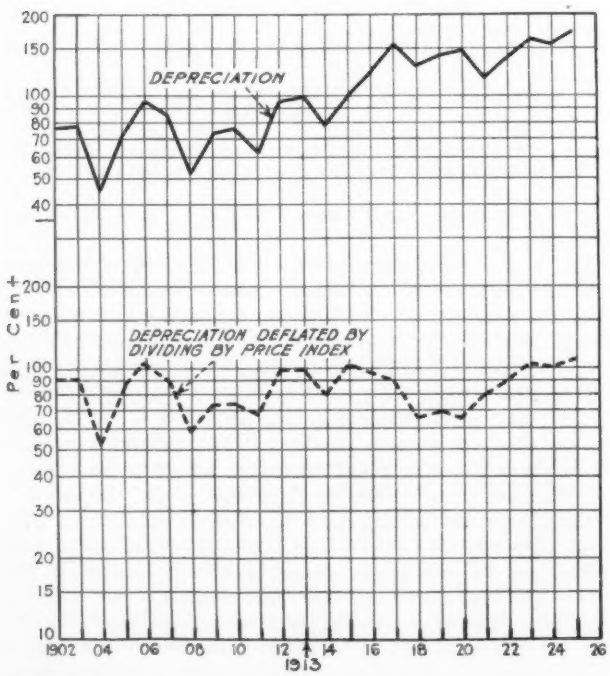

Fig. 3 Chart Showing Depreciation Account of U.S. Steel Corporation in Raw Dollars, and the Same Account Deflated by Dividing by Price Index—Year 1913 Taken as a Base or 100 Per Cent

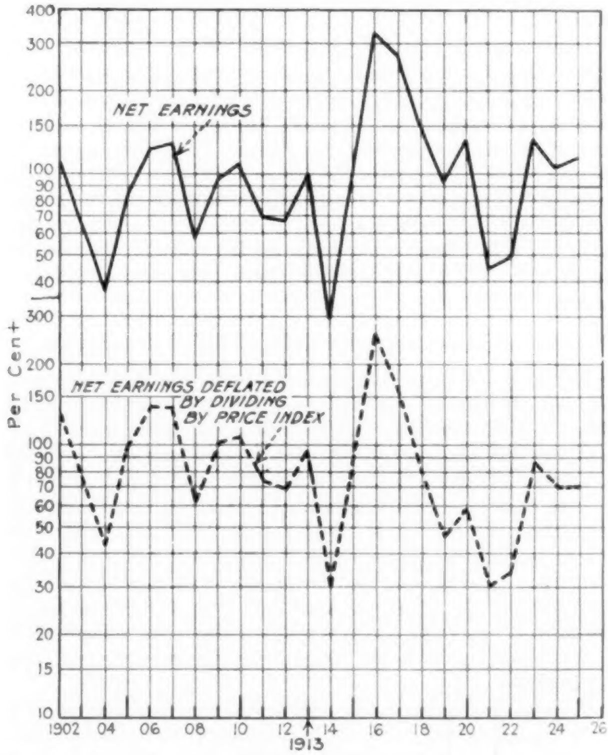

Fig. 4 Chart Showing Net Earnings of U.S. Steel Corporation in Raw Dollars and Also When Deflated by Dividing by Price Index—Year 1913 Taken as a Base or 100 Per Cent

From the chart alone one could fairly conclude that the depreciation account does not reflect true economic depreciation allowance. This conclusion is backed up by the words of Judge Gary himself, speaking to the two annual stockholders' meetings preceding his death. In answer to stockholders' questions he stated that the so-called surplus of the corporation was deceptive because the depreciation accounts were based on the cost of acquisition or, as he put it, on old plant values. He pointed out that under present price conditions the amounts charged off each year would not replace more than one-half of the very same kind of plant.

Depreciation of course is only one factor to be considered in the final situation for the stockholder as shown in Fig. 4 giving the curve of net earnings for stock, both preferred and com-

mon. On this chart, even the upper curve of raw dollars shows a slightly declining trend from 1902 to 1914, in spite of the increasing trend of production. But when we come to deflate the net-earnings curve, we readily see that the more steel that was made and the more of the so-called surplus that was plowed back each year into the property of the corporation, the less purchasing power the corporation has been earning for the stockholder.

This showing would be still worse if we were to deduct from earnings the purchasing power that should be transferred to and recorded in the depreciation account in order to provide funds that would keep the plants up to their original point at the replacement costs.

When such a large, well-managed concern as U.S. Steel can suffer from the dollar delusion as this analysis of its reports shows to be the case, is it not likely that many thousands of smaller, less-well-managed concerns must have suffered proportionally much more?

Managers of machine shops have led the way, ever since Frederick W. Taylor pointed it out, in increasing the efficiency of industrial production through application of some fundamental rules of production management and control. Today there seems to be more scientific production management in machine-shop practice than in any other large division of production. Why should not machine-shop managers use their ability to apply sound economics to the business side, to cost accounting, to executive accounting, to pricing, as they have done to production?

The author feels that when they do this to the same extent as they have done the other, they will show even greater profit results than those shown by their work in production. He even believes that much of the gain they have made on the production side has been thrown to the winds on the business side. For that reason managers have not had funds enough at their disposal to buy machinery which will make even greater gains that are possible on the production side. And so we come back to the point where we began this discussion, namely, that profit is the end of business, and it is the duty of management to earn true profits and not be deceived by bad figuring as to what that profit is.

Types of Steel Used by Railroads

The paper here abstracted describes mainly the existing conditions, but here and there makes reference to the history of the materials.

Rails. Rolled manganese rails have not been successful due partly to increased cost and partly to the extreme malleability of the metal. The metal does not break even when a transverse fissure forms in the head and extends down nearly to the base, but is twisted out of shape quite easily. Rails of special alloy steel failed through formation of transverse fissures and other defects. Heat treatment promises an improvement in rails, but has not gone far enough yet.

The main dependence at present, as we all know, is placed upon open-hearth rails rolled from reheated blooms—not rolled direct without reheating, as was formerly the custom. This reheating of blooms has lessened the stresses in the finished rail, as compared with the former practice, and has resulted, as would be expected, in a decided decrease in the formation of transverse fissures. Mere increase in size of rail section does not necessarily imply betterment in quality and in fact the reverse is usually expected, and today we are striving to secure the same fine-grained structure that was characteristic of the rails of small section years ago. This will come together with other improvements in manufacture, and our rails of the future will be tougher and stronger with higher elastic limit and better able successfully to meet increasing demands.

Boilers. There is a great demand for stronger and more resistant materials. Nickel-steel plates were rolled and are in use on the Canadian Pacific and other roads, the elastic limit being increased from about 36,000 to about 46,000 lb. per sq. in. This change rendered possible a thinner plate with decreased weight, while at the same time maintaining or increasing resistance to stress.

A still later development and a very interesting one is the use by the Canadian National Railways of a special steel for the boiler shells of their most recently designed locomotives. The material is termed "silicon steel," but this is a misnomer for it is merely a high-grade steel with somewhat higher carbon and manganese than usual and with a minimum of 0.18 per cent silicon—about the same proportion of silicon as has been present in good grades of steel for many years. The physical properties of this steel are excellent for the purpose, with elastic limit, tensile strength, and ductility practically the same as though the more expensive nickel, chromium, or vanadium steel were used, while the relatively high elastic limit permits the use of a thinner plate with a considerable decrease in weight, at the same time allowing an increase in boiler pressure. This is effected at a moderate cost through use of materials found in every-day practice at all of the mills.

Locomotive Frames. The properties of greatest importance in locomotive frames are toughness and resistance to shock, as well as ability of material to withstand, without becoming brittle, temperatures at times far below zero.

Staybolts. The steel staybolts proved so satisfactory that they are now standard practice on the Canadian National Railways and are also largely used upon the Canadian Pacific Railway.

Tires. In the United States today the Specifications of the American Railway Association and of the American Society for Testing Materials are the usual standard, calling for tensile strengths ranging from 105,000 to 125,000 lb. per sq. in., with elastic limits about one-half of these amounts. The practice of the Canadian roads has, however, for a good many years standardized upon heat-treated tires, with elastic limit at about 90,000 lb. per sq. in., with relatively fine grain and good ductility. Such tires as these give greatly increased mileage as compared with the A.R.A. and the A.S.T.M. type, and are far more serviceable.

Spring Steel. For many years comparatively few changes were made in composition. The American practice called for steel with about 1 per cent carbon and below 0.50 per cent manganese, while the English preferred a lower proportion of carbon with higher manganese—about 0.80 per cent of each—and equally good general results were obtained provided that correct heat treatment was given. In comparatively recent years alloy steel has been used largely for this purpose, and great improvement has resulted, due partly to the properties given by the alloys, and considerably to the uniformity secured as a consequence of careful attention to the heat treatment of the springs. (Robert Job, Vice-president of the Milton Hershey Co., Ltd., Montreal, Canada, in a paper before the *American Institute of Mining and Metallurgical Engineers*, New York, Feb., 1928, abstracted from mimeographed preprint, *g*)

Industrial Cooperation in Education

By A. C. Jewett,[1] Pittsburgh, Pa.

This paper indicates the need of more training and education for all employees, including the semi-skilled and unskilled. It points out that this can be effectively and inexpensively obtained. Data are given pertaining to night-school instruction in the Pittsburgh district.

The efficiency of industrial labor can be greatly improved if more attention is paid to training the average employee for his work. Furthermore, by lending encouragement to his general education also, a contribution may be made toward better citizenship and stability of labor. City evening schools offer a tool to the hand of industry for greatly improving its training program if it will but adopt a constructive policy of employee training in its shops and cooperate with those institutions which offer evening instruction. The Pittsburgh district offers a good illustration of the facilities which are available in every city to a greater or lesser extent, and which might be more profitably used by industry. Some one in each establishment should give personal attention to the possibilities of improvement of industrial efficiency through training and education.

Where the opportunity for bettering one's training for his occupation exists, industrial employees in large numbers are certain to take advantage of it. The Federal Board for Vocational Education has reported that vocational enrolments in the United States increased somewhat more than 500 per cent in the years from 1918 to 1926. This indicates that both the demand and the facilities for vocational training are now quite generally developed.

In an industrial country where improved equipment and working conditions call more and more for better training, this is but a natural condition. Seventy per cent of all children drop out of school before entering the high school. They have received at best only a grammar-school education, and practically no vocational training. They find employment, and in the cities this employment is largely industrial. In the country as a whole, about 30 per cent of those gainfully employed are engaged in manufacturing and mechanical operations.

In a great many cases a man's vocation, his life work, is a matter of chance influences. In the beginning of his career he finds himself employed before he is fitted for his employment. By a process of transfer or discharge and reemployment, his work becomes adjusted to his aptitudes. He is then in a position to profit by further training and education. Now this young man who has left school and gone to work is not to be pitied. He may yet obtain the best possible education in every sense of the word. That depends upon himself, his employer, and others who may inspire his efforts. That is to say, there is exceptional value in that education which is put to practical test and use as soon as acquired.

For all positions in industrial employment men need a certain amount of knowledge and skill. The amount varies according to position. These are commonly classified as executive, skilled, semi-skilled, and unskilled. The executive and technical presumably need the highest type of general and professional education. The skilled group embraces tradesmen who have served an apprenticeship of about four years' duration. The semi-skilled are largely machine operators. But these classifications are old-fashioned. It should now be the ambition of every industrial executive to have only skilled men in his organization; not semi-skilled or half-competent, unskilled or incompetent. The day of unskilled labor has passed. It has long been shown that economy of operation demands skill in even the most ordinary of tasks.

Taylor demonstrated that by analysis and time study of the work, and instruction of the workman on such jobs as shoveling or handling of pig iron, the daily output could be increased to three and one-half or four times that of uninstructed laborers. In a measure similar results can be realized with many so-called unskilled operations. Every sort of employment may be studied, analyzed, and taught with profitable results. The difference between the skilled and the unskilled, as now classified, is not intrinsically a matter of relative skill but of the number of skills which a man has. An element of skill may be as simple as an elementary motion. The skilled toolmaker possesses many skills: skill in measurements, in machine manipulation, and manual skill with each of many tools. Combined with these various skills must be a proportionate amount of knowledge. All industrial training needs to be a combination of knowledge and skill, of knowing how and why as learned from study or instruction, and facility of performance acquired from continued practice.

If all industrial workers are to be best trained for the work they are given to do, the industrial organization must give more consideration to training. Practically no industrial enterprise can hope to look entirely outside itself to a source of competently trained workers. A large part of the training of their personnel they must themselves direct. In so far as facility of performance or skill which comes from practice is concerned, they can best do their own training. For the teaching of knowledge, the how and why, the vocabulary and technology of the work, they may often successfully call upon outside educational institutions. Thus, in the last analysis, there is opportunity and need for a well-organized cooperation between factory and school. This should not only improve a man's value through better vocational training, but through general education improve his value as a citizen and employee.

A well-balanced education must prepare a man for many things. It should train him for vocational competence, for citizenship, social relations, physical efficiency, and for his leisure occupations. Such an education is, in many cases, barely approximated by those who devote their full time up to the age of twenty-three or twenty-four to secure the benefits of preparatory school, college, and professional school. On the other hand, there are many who achieve complete and efficient educational results through their own efforts in making use of the various means available now in nearly every large center of population. And this, too, while they are gainfully employed and, in most cases, self-supporting.

As will be shown, the school facilities already exist. There is needed a clearer conception of the teaching task that lies within the industrial establishment itself. There is also needed a definitely organized plan of coordination of the educational and training efforts of industry with those of the existing educational institutions.

Opportunities for this are found in all large centers of population. These are also, naturally, large centers of industrial employment. As a rule, the initiative for carrying on outside

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[1] Director, College of Industries, Carnegie Institute of Technology. Mem. A.S.M.E.

For presentation at the Spring Meeting, Pittsburgh, Pa., May 14 to 17, 1928, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

study and for attendance at evening classes arises with the individual himself rather than with his employer. Industrial employers might find real advantage in a closer, well-formulated plan of cooperation with the educational institutions in their districts.

Are Night-School Students Good Employees?

Pittsburgh may be considered representative of what is being done and of what may be done in this respect, in that it offers every sort of educational training in evening classes, as well as in the regular day classes. The Carnegie Institute of Technology enrolls about 4000 students in its night classes. This enrolment is growing each year at a rapid rate. In several instances there is a very large number of men enrolled as students who are employed in the same industrial establishment. See Fig. 1 and Table 1.

TABLE 1 COMPANIES REPRESENTED BY LARGE NUMBERS IN THE NIGHT-SCHOOL STUDENT BODY OF THE CARNEGIE INSTITUTE OF TECHNOLOGY

	1927–28	1921–22
Westinghouse Electric and Manufacturing Company	419	100
Carnegie Steel Company	164	66
Philadelphia Company	131	39
Koppers Company	110	5
Jones and Laughlin Steel Corporation	92	13
Bell Telephone Company of Pennsylvania	81	11
National Tube Company	75	21
Duquesne Light Company	74	29
Union Switch and Signal Company	70	6

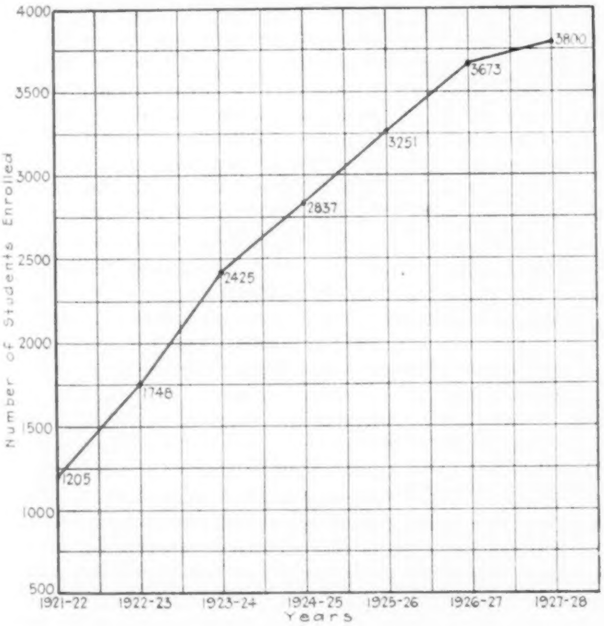


Fig. 1 Number of Students Enrolled in the Evening Classes by Years, Carnegie Institute of Technology

This has facilitated some studies which have led to very interesting results. For example, an analysis of the Westinghouse group revealed the following interesting facts.

1 In relation to men engaged in similar work, classified by ability or value to the company, 41 per cent were in the top quarter, 55 per cent were in the middle half, and 4 per cent were in the bottom quarter.

2 93 per cent of the men were taking outside educational work in line with their best interests.

3 22 per cent will have little opportunity to use their training in their present position.

4 12 per cent were top-quarter men both in school and in relation to men engaged in similar work.

5 The 4 per cent that were in the bottom quarter were all failures in school.

In other words, Mr. Coler, Director of Education for the Westinghouse Company, tells us that the night students instead of neglecting their daily work, as many employers might imagine, were in reality acting as pace setters for the other men in their departments engaged in similar work.

The progressive business manager has been convinced that education pays. This is shown by the demand made by some managers upon the personnel department head that a definite percentage of the employees take up some form of educational work.

The Aluminum Company of America attempts to keep 12 per cent of its men engaged in some kind of school work. The management believes that one out of every eight or nine men should be ambitious enough to prepare himself for a better position. With only a few of its men taking educational courses, the management would feel that it was manned by an inferior group.

Naturally, the primary interest of the employer is to insure vocational competence. This pays direct returns in dollars and cents. But there is indirect value to the employer in those other educational aims; in physical efficiency, certainly—good citizenship and cultural interests make for industrial peace and harmony. Employees whose spare hours are spent in study are likely to be more contented than their fellow-workmen of equal mentality whose spare time is spent otherwise than in organized study.

It is estimated that the labor turnover in the United States in 1926 was 125 per cent of the number employed. The cost of such turnover is well understood, and the possible savings through its reduction are apparently still large.

At present there is a trend to encourage education both inside and outside of the plant, but a correlation of these two forms of training is often lacking. Safety courses, foreman training courses, and apprentice training courses are typical of many that have been organized with success in mills and factories. These courses afford the management an opportunity to impress various ideas and methods upon foremen and workmen. Managers of many firms encourage their men to follow outside courses of study as a means of preparing for future openings that require better-trained workers. Many large corporations even investigate by poll each year to see what percentage of their employees are improving themselves through educational work outside of their working hours. In the past, business has fostered education with the attitude that it must be a good thing since so many employees wanted it. Many managers, however, in fostering education, have failed to see the possibilities of a definite, established policy, or of cooperation with the public schools, colleges, and universities.

A plan that is being developed is as follows: The company designates some one as educational director or adviser. The outside night-school director supplies him with complete catalogs and schedules of subjects offered, fees charged, and in general all details necessary to enable the company representative to advise prospective students regarding courses as well as a school official might do. The company representative further undertakes to so arrange the employee's assignment that it will not conflict with night-school attendance. In the past many students have had to give up their school work because of a change in their assigned work, as, for example, to a night shift or to a plant in some other city. If a company representative has knowledge of the employee's educational plans and pursues a constructive policy of assistance, most of such discouragements may be avoided. The conduct of an employer's educational program is not a simple matter. It calls for great tact, both in association with the em-

ployee and with his superiors. In some cases the employee does not care to have his employer know about his studies. He may even be preparing to change his job. In other cases superiors may be out of sympathy with a man's study program.

The educational institutions are already prepared to cooperate with the industrial representative in any way that will develop and improve the training program. An appreciation of the valuable possibilities of a constructive educational program should insure support from the company officers of a sort that will guarantee its success.

There are in the Pittsburgh district a number of outstanding examples of progressive educational policy and cooperation with established educational institutions. One of these, the Westinghouse Electric and Manufacturing Company, is already widely known for its educational work. Under the direction of Mr. Carl S. Coler it operates its own educational program of the widest scope, a part of which was recently described by Mr. Coler in a paper before this Society.[2] This company also issues an annual pamphlet entitled "Educational Opportunities," which gives a very complete account of opportunities available to its employees. As a result over 4000 employees are now carrying on study courses of some sort. Another example is that of the Philadelphia Company, which is made up of the Pittsburgh Railways Company, the Duquesne Light Company, the Equitable Gas Company, the Pittsburgh Motor Coach Company, and several smaller companies. The Philadelphia Company has some 2000 persons enrolled in study courses which it conducts in cooperation with outside educational institutions.

TABLE 2 EXTENT OF EVENING CLASSES IN PITTSBURGH PUBLIC SCHOOLS

	1925–26	1924–25
School buildings used	44	44
Evening high schools	8	8
Evening trade schools	3	3
Evening elementary schools	23	22
Community centers	8	9
Men students in all departments	8,160	7,931
Women students in all departments	9,726	9,466
Total registered students	17,876	17,397
In evening high and trade courses	9,637	9,023
In evening elementary centers	8,239	8,374
In self-supporting activities	13,425	15,851
Attendance at lectures and entertainments	39,809	27,742
Total, all activities	71,110	61,990
Commercial and academic studies	6,521	5,787
Elementary English and rudimentary studies	4,160	4,332
Household arts and economics	4,334	4,917
Industrial training and trades	2,334	2,016
Physical education	921	895
Musical studies and practice	420	376
Arts and crafts courses	327	224

Mr. Baum, Educational Director of the Philadelphia Company, has said of their education policy:

> A careful survey of the present facilities of local schools and the extent of their industrial service program indicated that they were adequately equipped to provide for practically all needs of our industry and invited an opportunity to render this service. Duplication of these available facilities by industry would not seem to be justified economically.
>
> Approximately 80 per cent of the vocational and other courses in the schools were approved for use as a part of the educational program of this company. Some changes were arranged for the other 20 per cent.
>
> On the basis of the above analysis our industrial educational program should propose to accomplish three major objectives: first, to ascertain the needs peculiar to the public-utilities industry that are not presently provided for by the general educational curriculum as sponsored by our several local schools of elementary, secondary, college, and technical rating; second, to determine a definitely coordinated program of courses, simple in structure but consistent in form, that will provide for these special needs of the industry; third, to effect a cooperative arrangement with the proper educational institutions that will permit the correlation of the special industrial courses with their general educational program and provide a practical means for making these and other related educational opportunities available to our employees.
>
> The program is divided into four sections: preparatory, technical, administrative, and operating and special training, each of the last three sections representing a distinct phase of industrial activity.
>
> This sectional division not only makes possible a more practical basis for coordinating the program with that of local educational institutions, but also simplifies the employee-student's task of electing a proper course of study covering a desired phase of the industry.

[2] Trades Training, by Carl S. Coler. MECHANICAL ENGINEERING, vol. 48, Mid-November, 1926, p. 1257.

This company also issues an annual leaflet, "Educational Opportunities for Employees of the Philadelphia Company and Affiliated Corporations," and urges employees to consult with either its Bureau of Education or department educational representatives concerning their educational problems.

It is to be hoped that in time every large industrial establishment will have designated some one in its organization as educational director, charged with the task of securing the full and complete training of every employee for his position and of cooperating with the school authorities in utilizing existing educational facilities more profitably. The advantages of such a plan may well be summed up on the basis of recent experience as follows:

TABLE 3 SUBJECTS TAUGHT IN PITTSBURGH NIGHT SCHOOLS AND THE NUMBERS STUDYING THEM

HIGH-SCHOOL STUDIES			
Algebra	229	Bookkeeping	803
American History	110	Business English	649
American Literature	46	Calculating Machine	36
Advertising	18	Chemistry	102
Civics	29	General Science	35
Commercial Arithmetic	333	Higher English	956
Commercial Law	135	Latin	95
Economics	45	Penmanship	185
Expressional English	138	Physics	21
Electricity	71	Public Speaking	88
English Literature	32	Salesmanship	231
French	242	Shorthand	1480
Geometry and Trig	36	Spanish	114
General Mathematics	67	Typewriting	1698
HOUSEHOLD ECONOMY			
Sewing and Dressmaking			2340
Cooking and Dietetics			758
Millinery			1236
PHYSICAL EDUCATION			
Nursing, Health Instruction, Physical Training, and First Aid			921
MUSICAL STUDIES AND PRACTICE			
Chorus 349		Sight Singing 60	Orchestra 78
INDUSTRIAL AND TRADE TRAINING			
Mechanical Drawing	606	Plumbing	22
Woodwork	609	Paper Hanging	40
Machine Shop	277	Sheet Metal	12
Auto Mechanics	212	Trade Mathematics	20
Carpentry	130	Tailoring	24
Trade Electricity	228	Study of Occupations	17
Building Construction	120	Show-Card Writing	24
ART EDUCATION			
Drawing and Design	82	Show-Card Writing	24
Commercial Art	88	Basketry	78
Decorative Art	53		
ADVANCED CITIZENSHIP			
Petitions for Naturalization			121
LIP READING			
Partially Deaf Adults			24

Night students set the pace for the other men in their departments.

Mental training leads to contentment and reduces labor turnover.

An educational department functioning in the mill or factory or through outside sources enables the management to transmit ideas to employees in a tactful way.

Labor problems are often better settled by education than in any other way.

THE PITTSBURGH DISTRICT REPRESENTATIVE OF MODERN EDUCATIONAL FACILITIES

In the Pittsburgh district every branch of educational activity

is represented from the elementary school, through secondary and trades schools, to the college and professional school. Practically all instruction in this field is available in both day and evening classes. The extent of the evening classes in the city public-school system is shown by Table 2. It is to be noted that the enrolment is large in all classes of study from the elementary up to regular high-school subjects. During the last few years the city has operated a standard evening high school.

The subject-matter studied is shown in Table 3. Particular attention is called to the Industrial and Trade Training section in which the enrolment is smaller than it should be if the value of the opportunities offered employers were properly appreciated.

The field of education represented by the public-school system will be better served as time goes on and will be in keeping with public demand. The attitude of public-school authorities is well shown by the following quotation from one of their reports.

> The expansion of public-school extension is not only a legitimate use of public funds, but a profitable investment for any school district. Extension education is therefore a growing as well as a staying part of public-school work. Its expansion is both legitimate and necessary. Its cost will be real economy, its administration and management call for the spirit of whole-hearted service and the vision of a better community for all the people. It is the field in which our best national hopes will find complete and abiding realization.

In this connection mention should be made of the part-time cooperative day courses of the city trade schools. These are especially for training apprentices. The school authorities find the boy and the job and bring them together. The boy becomes a regularly indentured apprentice. He alternately attends school two weeks and works in the factory two weeks. To be accepted for this training he must be sixteen years old or over, have completed the eighth grade of school, and have had at least one semester of training in the trade he wishes to enter. As a matter of fact, the 120 to 125 boys now enrolled under this plan average better than these minimum requirements. They have completed the ninth grade, average seventeen years of age, and have had one year's experience at their trade. This is not the total of apprentices in the public school system, however, as the night schools enroll about 500 apprentices who are required by either union or employer regulations to attend school from four to eight hours per week. The trades principally concerned in the program are carpenters, brick masons, electricians, and plumbers.

For those who require instruction of more mature or advanced grade than that offered in the city school system there is available a multitude of advanced courses, which include a large proportion of the subjects of all sorts contained in the regular college catalogs. These are offered by the University of Pittsburgh, Duquesne University, The Extension Department of the Pennsylvania State College, and by the Carnegie Institute of Technology.

These are all public institutions of non-profit-making character. No consideration is here given to commercial colleges and correspondence schools whose work is naturally a large factor in the general field preparing for industrial employment.

The University of Pittsburgh offers courses in the College, the Graduate School, the School of Business Administration, the School of Engineering and Mines, and the School of Education, and has an evening enrolment of a little more than 2000.

Duquesne University offers courses in the School of Accounts, in the Law School, and in the College of Arts. It has an enrolment of about 1000.

Data regarding the extension courses of the Pennsylvania State College are not available at this writing, but it is understood that this institution is prepared to give any of its courses for which there is sufficient demand and which is not otherwise available.

The Carnegie Institute of Technology has a night-school enrolment of 3800. The details of this enrolment, showing the variety and enrolment of courses, are shown in Table 4.

TABLE 4 NIGHT-SCHOOL ENROLMENT AT CARNEGIE INSTITUTE OF TECHNOLOGY

College of Engineering	Men	Women	Total
Chemistry	71	1	72
Civil Engineering	128	...	128
Electrical Engineering	265	...	265
Mechanical Engineering	183	...	183
Metallurgical Engineering	96	...	96
Unclassified	105	...	105
Electives	4	...	4
Total	852	1	853
College of Fine Arts			
Architecture	97	1	98
Drama	35	26	61
Music	35	25	60
Painting and Decoration	141	98	239
Sculpture	15	6	21
Electives	2	33	34
Total	325	189	514
College of Industries			
Electrical Equipment	254	...	254
Radio	29	...	29
Electric Meter Practice	15	...	15
Storage Battery	17	...	17
Sheet Metal	108	...	108
Metal Lath	18	...	18
Welding	76	...	76
Plumbing	133	...	133
Heating and Ventilating	15	...	15
Masonry	80	...	80
Carpentry	86	...	86
Estimating	58	...	58
Pipe Drawing	7	...	7
Structural Drawing	170	...	170
Architectural Drawing	146	...	146
Mechanical Drafting	289	...	289
Machine Shop	78	...	78
Pattern Shop	44	...	44
Foundry Shop	5	...	5
Forge Shop	14	...	14
Automobile Maintenance and Repair	181	...	181
Practical Chemistry	52	...	52
Printing	116	...	116
General Studies	282	...	282
Industrial Education	33	...	33
Electives	106	21	127
Total	2412	21	2433

Summary—Night

College	Men	Women	Total
Engineering	852	1	853
Arts	325	189	514
Industries	2412	21	2433
Total	3589	211	3800

In addition to the wide variety of subjects already given, the catalog announces:

> In order to make the Carnegie Institute of Technology as useful as possible to the Pittsburgh district, classes will be organized to study subjects not previously announced in publications, whenever the demand for them becomes clear. On the other hand, if enrolment in an announced class is too small to warrant its continuance, the class may be given up.

Admission requirements are simple. As a rule a student need but be over eighteen years of age (seventeen in some cases) and be competent to undertake profitably the desired studies. To become a candidate for a diploma or degree in the College of Engineering an applicant must have completed a satisfactory four-year high school course (15 units) and have included certain mathematics, physics, and English.

A typical night-school program consists of three nights per week of two hours each, extending from about October 1 until April 30. If this sort of schedule is pursued for four years in the vocational or trades courses of the College of Industries a certificate of graduation is awarded. A similar schedule in the College of Engineering, if carried for six years, will lead to a diploma, and in eight or nine years a regular baccalaureate degree can be earned. In the College of Fine Arts it requires, as a rule, five or six years to obtain a certificate. Considering the specialized interests of the students, it is natural that the majority complete

some particular unit course and then drop out without attempting to complete the full requirements for certificate or diploma. However, 67 per cent of those who enroll take the final examinations in their subjects at the end of the year. Table 5 shows the numbers who have been graduated each year and have received the appropriate certificate or diploma.

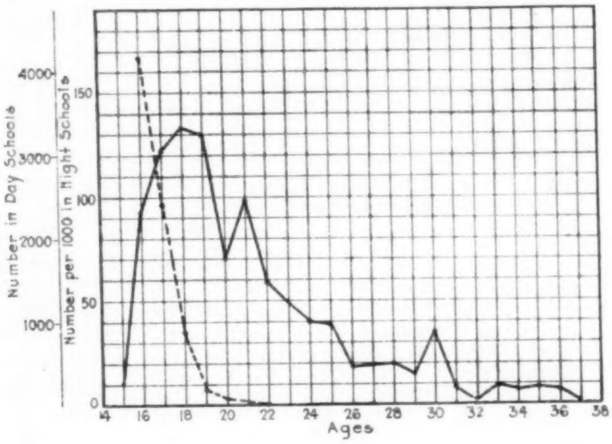


Fig. 2 Comparison of Ages of Students in the Pittsburgh Public Schools

(Full line, night-school students; dotted line, day-school students.)

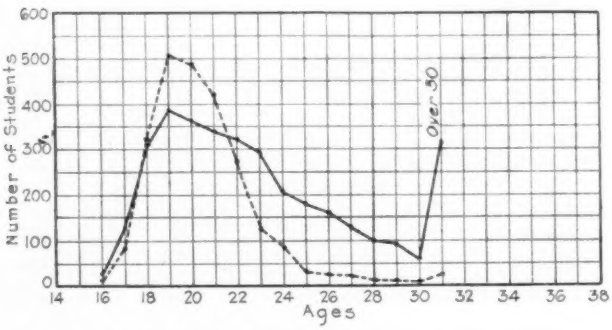


Fig. 3 Comparison of Ages of Day and Night Students, Carnegie Institute of Technology

(Full line, night-school students; dotted line, day-school students.)

Figs. 2 and 3, showing the ages of the students, indicate that the night students are a little more mature than regular college students. The average age of these latter at the Carnegie Institute of Technology is 20.5 years as compared with an average of 23.2 years for night students. The large number of night students over thirty years of age should be noted. Men of over forty years are not at all uncommon.

The majority of those attending come from the city and surrounding towns within a radius of thirty miles. There are numerous instances of students whose homes and work are much farther away, and in one or two instances of men holding railroad passes, the distance traveled each way by regular night attendants is as high as 100 miles.

As the great majority of the students pay their own expenses they must find it worth while to carry on night-school work. In only a few cases do employers pay the student's tuition. Naturally, many cases of the real value of night-school instruction come to our attention. No statistics can adequately show the average improvement of students and to quote selected cases of men who have advanced themselves rapidly to large salaries or responsible positions might be misleading. The opportunity for great personal advancement is available to all those who have the necessary qualifications, plus persistence.

TABLE 5 COMPARATIVE TABLE OF GRADUATES BY YEARS

Year	Engineering	Fine Arts	Industries	Total
1909	...	..	51	51
1910	31	..	19	50
1911	19	..	19	38
1912	11	1	18	30
1913	10	..	23	33
1914	8	1	22	31
1915	13	..	24	38
1916	14	..	23	37
1917	13	1	34	48
1918	12	..	17	29
1919	...	2	...	2
1920	16	1	6	23
1921	8	..	17	25
1922	10	1	10	21
1923	11	1	23	35
1924	11	3	18	32
1925	8	..	19	27
1926	5	2	17	24
1927	7	1	36	44
Grand Total....	207	14	416	618

Conclusion

The object herein has been to call the attention of industrial executives primarily to these facts, namely:

That there is need for more attention to training all employees in any establishment for maximum skill in the work of the position held.

That part of the needed training can best be done by the industrial establishment and part by existing educational institutions.

That in many large centers of population the educational facilities and opportunities are very complete.

That every establishment should have some one whose duty it is to insure that every employee is properly and fully instructed in those matters which will make him more valuable. It should be his duty to see that existing educational institutions are used to the best advantage and to help to coordinate their teaching with the training of his establishment where this can be tactfully managed. In large establishments at least one person should give this his entire attention.

Modern Lacquer Automobile Finishes

Discovery of a method of producing cellulose-nitrate lacquers in a highly concentrated form of low viscosity without impairing their film strength makes possible the giving of as much protection with one coat of this present automobile finishing material as with three or four coats of the earlier lacquers.

The modern lacquer consists of a solution of pyroxylin, plasticizer and resin, or gum, into which a suitable pigment or combination of pigments has been ground. The material used to dissolve these ingredients is a mixture of solvent and non-solvent, or diluent, in proper ratio.

When a lacquer dries, the solvents and non-solvents evaporate, leaving a film consisting of the solid ingredients. In the older oil-type paint and varnish finishes the oil takes up oxygen slowly from the air and is thereby changed from a liquid to a solid. Therefore it is said that a lacquer dries by evaporation and a paint by oxidation.

High-grade lacquer finishes are being applied at present with only three minutes' drying between coats at 125 deg. fahr. according to Dr. Given, of the E. I. du Pont de Nemours & Co. After the last coat is applied it is advisable to dry for about fifteen minutes at the same temperature before the sanding operation. Adequate ventilation is necessary in the drying chamber, as lacquers dry by evaporation. This schedule is about all that could be desired.—*S.A.E. Journal*, April, 1928.

Principles of Apprenticeship Organization

By BEN. S. MOFFATT,[1] SAN LEANDRO, CAL.

INDUSTRIAL shops are requiring increasingly that every man, every piece of equipment, and every function be in accordance with standards, predetermined and systematically planned. An apprentice-training program is not different. To succeed, it, too, must be recognized as a function depending upon the same principles. Unless this recognition is given and apprentice training is made a part of the administrative organization as a functional operation, it will remain an uncertain element, increasingly difficult and costly to maintain.

For the establishment of a successful apprentice-training program, either in a plant or a combination of plants, it is desirable to start with a survey to determine the apprentice-training needs and potential training capacity, to be followed by an audit of any existing apprentice training and organization. The desired standards can then be established and a system organized to meet these standards. This will require a careful investigation of the fitness of the plant personnel, shop methods, and production processes to assist in the program, and a determination of the number of apprentices that can be properly trained. A final point to be considered is the method of apprentice shop supervision.

Methods to Be Employed in Conducting the Survey

The properly carried-out survey will list all jobs calling for trade skill and knowledge of equipment, and analyze and chart them showing progress sequence of training values in types of work for each training requirement. By using a standard trade analysis chart and extending it to admit the listing of unit values for corresponding checking levels, a measure of the standards of training necessary can be secured by checking the corresponding values throughout the listed findings and those of the standard lists. The equipment of each shop should be examined, listed, analyzed, and charted in the same way, showing equipment types and their functions.

Methods of Determining Training Values

In order to determine the training value of the work it should be recharted in the same way, but to show the progress sequence of training values in types of work for each checking level.

For a successful audit of existing systems of training the movements of the apprentices throughout the course should be listed in sequence, and their work experiences between movements entered upon standard analysis charts in the sequence in which movements occur, giving type classes of work and objectives and machine equipment values, and their progress through the work of each period between movements treated in the same way. A simple comparison of the charts will provide the audit.

The Establishment of Standards

Before the training program can be adopted, standards should be established based upon the charted values previously determined. They may be greater or less than or equal to the accepted trade standards. There is an obvious advantage in at least meeting the accepted trade standards.

In establishing the standards it is of course essential that the shop or shops be such as to provide every unit of experience necessary to the standards, and that will permit of the proper training sequence being observed. Where any units of work experience are missing, they must be provided by some means in order to make the course complete and successful. If they cannot be provided then the proposed course must be limited to the portion that is practical or omitted entirely.

Naturally, shops differ even in producing the same product in the same volume. In one the productive system may afford a very effective operation of a given program of apprentice training, while that in force in the other may seriously interfere with its effectiveness or even prohibit it.

The coördinating functions involved in the operation of an apprentice-training program with the other shop administrative functions must be determined. It must be determined how the shop personnel, shop methods, processes of production, production schedules, and costs will fit into the training program. And the number of apprentices that may be trained, their period of training, and the apprentice material available must also be determined.

The traditional attitude of the various shop personnel to the apprentice, largely that of a ship's captain to a person traveling as supercargo, cannot continue. Where operations are planned to definite standards of costs and time and processing, apprentice training must be operated on the same basis. The personnel cannot escape the same functioning responsibility in connection with its operation as they accept in the case of the other work of the shop. They must be made to realize that the factors entering into an apprentice-training program are definite factors in production, that in so far as apprentice training falls short in a given function, it will affect other functions to the same degree. The personnel involved must be given a thorough preparation in the principles upon which the program is based, its operation in detail as part of the work of the plant, and the provisions to be established for its regulation.

Shop Methods and Processes of Production

Methods of processing the general work of the shop may obstruct the training program. These difficulties depend upon the type of shop in which the training is to be initiated. If it is engaged in the production of a mixed type of work, wherein the volume of any one type is insufficient to establish mass-production methods, and where a man is likely to be given any job involved in producing an article, it should be necessary only to bring the personnel involved to an understanding of the details of the system and their relationship and responsibilities regarding its operation.

Where, however, the skilled-trade work is subdivided into various classes and workmen confined to a given class, the order of the training work units will of necessity have to be changed to meet the various subdivisions of classified types of work, and this will involve the closest coordination with work schedules.

In shops where mass-production methods apply, but where the volume of production is insufficient to maintain straight-line progressive sequence of machine operations, the setting up of a program will meet with serious obstructions to the course as charted. A revision of the course must often be made to permit its adoption. This will not necessarily change its training value; but it will change the order of unit values in the trainee's progress and will entail considerable skill in determining the order of movements through the work units. This is largely due to the fact that there will be insufficient work to keep the required number of apprentices employed, unless they are allowed to do

[1] Supervisor Apprentice Training, Caterpillar Tractor Co.

Contributed by the Committee on Education and Training for the Industries and presented at the Annual Meeting, New York, December 5 to 8, 1927, of The American Society of Mechanical Engineers.

actual production work before they have reached the advanced stage necessary.

In those shops employing mass-production, straight-line progressive sequence of machines in operations throughout, and where all tools and special machine work are bought outside, the author does not see how it will be possible to establish a training program. Furthermore, a simple system of job training will suffice to maintain the desired standard.

Where, however, such a plant maintains its own means of equipment service, such as the construction and repair of tools, special equipment, and machines, together with other auxiliary work affording those experiences required in an apprentice training, a course can be carried out if confined to the auxiliary departments.

The Capacity of a Shop in Number of Apprentices

It is only when all the factors enumerated have been analyzed that the question of the capacity of a shop in numbering of apprentices begins to be clear. Once the training values and the system have been determined, this factor loses its vagueness and becomes subject to the same treatment as the other factors entering into the program.

The volume of a given class of work in a shop naturally limits the number that can benefit by those experiences. The number of apprentices that can receive these experiences thus becomes one of the factors in determining the total number to be in training, and this is again limited by the time necessary to give definite training in the different classes of work.

Another factor of importance in determining the capacity of the plant for training purposes is the character of the apprentice material available. For example, in a course planned to occupy four years, the movements through the various training units as established are to take place every three or four or, say, six months as the case may be. Assuming the period to be four months, then there will be three movements a year, making twelve movements during the course. With the work routed accordingly, and such elements of the work schedules as time and costs adjusted, with displacement of personnel to accommodate this work, and finally with regulations set up for its operation, it will be seen that the order of movements as planned must be maintained within reasonable limits, if any semblance of regularity is to be secured.

Each step of the course must prepare the trainee for the work of the next, within the limits of the periods set, and these periods cannot be adjusted to the shortcomings of any one group without causing a similar adjustment to the movements of other groups. In other words, these movements must take place at the same time and the time set. Thus if apprentice training is to be organized and established as a functional operation, a careful system of selecting apprentices becomes a first condition to its adoption.

The laws existing in any state or locality affecting the age at which apprentices can be employed, the regulations controlling the conduct of apprentice employment, etc. must of course be considered when planning the course.

The Cost of Apprentice Training

The costs of apprentice training become definite only in proportion as the course is carried out in accordance with the definite standards of the training system as planned and established. Having determined the training values of the work of a given plant and established their sequence in the course, every effort must be made to hold to the course as charted, if apprentice training costs are to be determined upon a basis affording them justice. Only when operated as a definitely planned and established functional operation in shop life can it be subject to the same cost analysis as other coordinating functions. Where this is done, apprentice training will demonstrate its ability to pay its way throughout every step in its program, and in many cases return to the management a considerable profit.

Shop Supervision

If a correct instructional order of work experiences is combined with those personal contacts that inculcate correct habits of work and attitude toward training, and the program is established as a functional operation, with the same cooperative responsibility of the personnel to its coordination with the work of the plant, special provision for instructional supervision should not be necessary, beyond that required for checking the progress of the apprentice training. By securing a correct instructional order of work, the apprentice's experience through one step, plus that direction given by the foreman to any help, will in a large measure be preparation for the work of the next. The apprentice, by observation, absorption, and assimilation acquires a knowledge of the work and activities surrounding him, and their relation to his training and the order in which they will affect him.

Apprentice Plant and Shop Committees

Where apprentice training is established as a coordinating division of shop work, with definite functions and regulations, it must function as planned if it is to be effective to those standards set up as its objectives. No shop committee or council or extra supervision are necessary. These standards, based upon an analysis of the training facilities within the plant, once applied and proved to be effective, cannot be subject to committee or council interference any more than the standards of the processing work by the planning department. Likewise its supervision cannot be subject to any but that authority responsible for the principles and practices upon which the program is based.

Trade Technical Instruction

Where the shop-work training experiences involve the application of certain trade, technical, and auxiliary information in the execution of a given job, then a knowledge of these technical and auxiliary elements, to the degree required, becomes an essential *factor* to the course *progression*, and must be secured by the apprentice by the time he needs to apply it.

The bearing which other so-called related or supplemental subjects have upon the training of apprentices, however desirable they may prove eventually to be, has not, up to the present, been established in a form sufficiently definite to be acceptable as a definite function in an organized course of the type under discussion.

That the apprentice must understand and be able to apply whatever technical and auxiliary information is required to fulfil the objectives of his shopwork training, must of course be conceded, as its direct relationship can be definitely identified and determined. Provision should be made for this training at the same time that the shop-work course is planned.

There can be no hard-and-fast rule as to where, when, or how this instruction shall be given; but it must be subject to those conditions incidental and peculiar to the work of the plant. Production schedules may prevent any regularity of class-room instruction, or even prohibit the giving of this instruction. Production costs may prohibit the additional cost of this instruction within the plant and by the company, even under conditions wherein the costs of the shop course, as established, are acceptable.

The correct instructional order of teaching required by these subjects may not be coincident with the training order of the work units to which they apply, thereby precluding the possibility of giving the degree of instruction required in the time allowed by the place of the work unit in the training schedule.

This may require serious revision of the early part of the shopwork schedule unless worked out thoroughly and the necessary adjustments made when planning the course.

Finally, any instruction to be given on the job must be confined to methods of application only. The apprentice should be sufficiently schooled in the applied subject before reaching the point in the training where he must use his knowledge. The regulation of the work and training schedules cannot be subject to the varied capacities of apprentices in acquiring proficiency.

The responsibility for the character of this instruction or any part of it cannot well be given to outsiders. The many and specific requirements peculiar to a given program, interwoven as they must be in every detail with those of the other divisional work, make it extremely difficult for any outside parties to secure that intimate understanding and merging of activities demanded of its operation.

Where outsiders must be used, they must be thoroughly familiar with the principles of production organization in accordance with the administrative policies and with the principles upon which the training program is built, and its responsibilities in operation; and be able to function within the organization accordingly. They must secure and maintain that intimate understanding of the individual apprentice which can only be secured by constant association with him under actual training conditions. They must be able to assure continued service under these conditions.

The Period of Apprentice Training

The period of apprentice training is more commonly four years, but varies from two to five years. It is quite possible that any or all of these varying periods may be justified under the conditions peculiar to a given program, but in any case and whatever the period, it must be based upon systematic analysis of the training values afforded by the work experiences the program provides and the time elements proved essential to meet their objectives.

Cooperative Apprentice Training

Two or more plants or parties may cooperate in the training of apprentices, either to supply those elements essential to the trade standard of training, or to provide increased capacity for training. But the author is inclined to believe that such cooperation should be accepted only in order that those elements which the plant is unable to provide may be secured. The objective of the training is to provide mechanics who are competent to meet trade standards, and should be carried out, where possible, in the industrial plant, the only place where the essential elements exist.

A complete measurement of the cooperation required, showing in detail the various values falling to each party, and the order of their coordination can be secured by the simple method of comparing the charted values when listed, for (1) the potential standard of the plant and (2) the proposed standard of the course. (See accompanying chart.)

	1		2		3		4										
CHECKING LEVEL	ACCEPTED TRADE STANDARDS		STANDARD REQUIRED		EXISTING STANDARD		POTENTIAL STANDARDS		PROPOSED ORGANIZATION								
1	TYPE JOBS	OBJECTIVES	TYPE JOBS	OBJECTIVES	TYPE JOBS	OBJECTIVES	TYPE JOBS	OBJECTIVES	TYPE JOBS	OBJECTIVES	EQUIPMENT	VOLUME	TIME ELEMENT	NO. OF APPRENTICES	ETC.	ETC.	ETC.
2																	
3																	

Comparative Analysis Chart of Apprentice-Training Values in Shop Organizations

(Accepted trade standards based on charted analysis as given in Bulletin No. 52, Trade and Industrial Series, No. 13, Federal Board for Vocational Education.)

Note: Chart of proposed organization to be extended to include any value applying to a given checking level both in shop work and in trade technical subjects.

					COÖPERATIVE DIVISION									
CHECKING LEVEL	POTENTIAL STANDARD		PROPOSED STANDARD		PLANT	OUTSIDE	EQUIPMENT	VOLUME	TIME ELEMENT	NO. OF APPRENTICES	MATH.	DRAWING	TRADE SCIENCE	ETC.
1	TYPE JOBS	OBJECTIVES	TYPE JOBS	OBJECTIVES	TYPE JOBS	TYPE JOBS								
2														
3														

Whatever the Order of Coöperation, its Extent as well as the Order of Coördination will be clearly shown by Charting in this Manner.

Cooperative Analysis Chart Showing Division of Cooperation and Order of Coordination

By charting the complete values for the potential standard, and also for the proposed standard, using a separate chart for each, the values that are listed upon the chart of the proposed standard, and are not listed upon the chart of the plant potential standard, represent that division of cooperation required by the outside parties.

By entering these values thus found in their corresponding levels upon the cooperative chart, the extent and character of both the plant program and that of the outside parties will be obtained, and also the order in which their coordination, to be effective, must function.

Forms of Cooperative Courses

In a situation wherein the training needs are discovered to be greater than the capacity of a plant, an analysis may disclose either of two different conditions: The complete range of work units necessary to the proposed course of training may not be provided within the plant, or if provided may be only in sufficient volume to train a limited number of apprentices, below the re-

quired number; or the complete range of work units necessary to the proposed course of training may not be provided, and though completed by outside cooperation, the plant may still be unable to train a sufficient number of apprentices to meet the needs.

The number of apprentices a given plant program can train is limited to the capacity of that checking level of work experiences with the smallest number capacity, multiplied by the number of checking levels. (See charts on previous page.)

A given plant may be able to provide work for checking level No. 3 only sufficient to take care of, say, one apprentice. It may at the same time be able to provide work for any one or even all of the other checking levels for a much higher quota, nevertheless, checking level No. 3 being an essential step to No. 4, the number entering No. 4 is limited to the number that can experience No. 3; again, it may be that the first seven checking levels can absorb ten apprentices while checking levels No. 8 and No. 9 can only absorb three and four, respectively. Then the first seven must be limited to three, if no other provision is provided to take care of the remaining seven apprentices when they reach checking level No. 8.

However, if the capacity quotas for the low levels are raised to that of the highest level by cooperation and the highest level meets the trade standard, then this is the only cooperation that is required. If the highest level is still short of the desired trade standard, then the plant has contributed all that is possible, and the principle of commercial practice has been observed.

The coordination of the parties to this cooperation in thus raising the capacity must function in accordance with their respective contributions as they are charted, the cooperating parties duplicating those elements of the plant program where necessary in order to balance the plant program.

After the plant program has been balanced to its highest contribution, a re-audit will again show its capacity in numbers as compared to that required, and the extent of the additional assistance necessary be measured. The missing elements to a trade standard must be supplied through cooperation.

It will be seen that with the plant program brought to its utmost capacity through cooperation, any further increase in the number trained must be taken care of elsewhere, by a duplication of conditions if the same standard of training is to be the objective. A cooperation of forces is not essential and the two programs may be entirely separated.

Alternating Cooperative Course

If a course of apprentice training was projected for a given plant and upon analysis it was found that approximately only 50 per cent of the essential elements were provided in the plant, and that the other approximate 50 per cent must be supplied by the cooperation of outside parties, then of course this 50–50 basis would apply.

Likewise, if the order of this cooperation was required in consecutive alternating periods of equal length, then of course this order of alternation would apply. Failing this ratio, and this alternating order, then this fifty-fifty cooperation cannot apply, and the regular half-in, half-out order of alternation cannot apply.

If this order of cooperation is adopted in the face of any other ratio, and in the face of any other required order of alternation, then either the training order-of-work experiences cannot be followed, or there must be a useless duplication of elements and a useless movement to conform with the order of alternation, or both.

Taking an extreme example: A cooperative course of apprenticeship training is planned for use in a plant in which all of the elements and also the required capacity in numbers exist, but for some reason or other a cooperation with outside parties is considered.

The plan calls for two weeks in plant and two weeks out, alternating throughout the course in this order. The course as planned is a course of four years, divided into twelve checking levels of four months each. In connection with a given checking level, the apprentice is to experience a given order of work in the sequence as planned for the course progression.

The apprentice works the first two weeks on the type jobs as planned and scheduled to him. He then moves out of the plant to continue a progressive sequence he could have continued, under continuity of commercial conditions, had he remained in the plant. Why?

There can be no question of the quality of his plant training in comparison with that given him outside, since, if each step in the program is an essential step to the next, this applies to the training within the plant as well as it applies to his training outside.

The training outside can be efficient only and in so far as the training inside has been efficient (we are speaking of an organized course). Again, whatever the objective may be, whether inside the plant or outside, it has been planned as a function of the next objective. If this function is not fulfilled, then training must cease.

It will be seen that a cooperative course under those conditions is a pure duplication only, and the alternate movements of the trainee from one cooperating body to another is but to comply with the alternation.

To duplicate equipment and organization is expensive, while to the apprentice the movement from one force to the other must remind him of the historical ditty of

"The Noble Duke of York
He had ten thousand men;
He marched them up a hill,
And he marched them down again!"

It is only when apprentice training is organized as a co-functioning activity that the selection of personnel is recognized as a major consideration. Here again this personnel must be in accordance with the type of shop and the number of apprentices to be trained and will fall generally into three classes: Organizer, Supervisor, and Instructor.

Before attempting any differentiation of this division, there is one requirement common to any personnel, whatever the program that is essential in all of its functions apart from any purely work requirement, which will be herein called "teaching proficiency."[2]

To teach effectively, one must have the teacher mind, plus training. The best mechanic in the world may be the worst instructor; the best shop executive the worst supervisor of teaching, and the best industrial engineer the worst organizer of this work.

The instructor will be unable to effectively impart his knowledge. The supervisor will be unable to effectively regulate the conduct in accordance with the training order of the charted course, and the engineer will be unable to identify in the work of the plant that order of work experiences in which they are required in the training and instructional demands of learning difficulties, and consequently be unable to correctly chart the course.

These teaching qualifications secured, the classification of personnel for the plant program will become simple from an examination of the charted values for an accepted course, by a

[2] See "The Instructor, The Man, and The Job," by Allen.

classification of the problems involved by any one familiar with shop organization and the selection of suitable help.

As this must be done prior to any work on the projected program, the use of any accepted standard and charted course must be used tentatively as a guide.[3]

Discussion

A WRITTEN discussion was contributed by W. S. Conant[4] in which he set forth that although the discussion and papers that dealt with the broad phases of apprenticeship training and actual experiences were valuable, they should be added to by expositions of concrete needs and difficulties. He considered the paper constructive because it met that need. He endorsed the idea of affiliating the training as closely as possible to the production program so as to reduce the expense, which he said was always the chief obstacle to apprenticeship training. He disagreed with the idea that time was always wasted when work was repeated in a different environment. He raised the suggestion that possibly this mere repetition of effort added greater skill.

J. E. Goss[5] expressed the opinion that the paper might give the false impression that the training system could be systematized to the point where it would function almost automatically. He explained that while the Brown & Sharpe Mfg. Co. did a great deal of job analysis, they nevertheless considered it a minor part and one that would not work at all without supervision and the proper support by all concerned.

He disagreed with the statement that regularity of instruction might not always be attained and insisted that to be successful the organization must guarantee regularity of instruction, preferably on shop time. He agreed that the responsibility for training could not be given entirely to outsiders, and declared that if the class work could not be given in the shop, the least that could be done would be to arrange for definite schooling outside and then cooperate with the school to make the program effective.

C. W. Cross[6] gave particulars regarding the New York Central plan, showing it to be a definite application of the author's suggestions.

In the oral discussion that followed C. F. Bailey,[7] speaking of the experience of the Newport News Shipbuilding & Dry Dock Company in training 225 apprentices, expressed their view as being that the object of apprentice training was not only to keep up the supply of skilled mechanics but also to increase production. He said their system provided for two afternoons of school work a week on the company's time and that they had lately been teaching the 17 supervisors how to teach. He added that Mr. Klinefelter had given them the Richards formula that efficiency varied in proportion to manipulative skill, technical knowledge, trade information, trade judgment, and trade morale or job pride. He had found that the most successful results always depended on the instructor, no matter what the trade, and that the successful supervisor must be a man interested heart and soul in the apprentice and his problems.

Jay R. Crowley[8] said that the State Education Department at Albany was in a position to aid and assist in the organization and instruction of apprentice classes through its adult education program. This program through cooperation with the public schools throughout the state included instruction in related subjects pertaining to the particular trade or occupation together with definite instructions in shop or trade practice. A program of teacher training was also provided for.

M. A. Stone[9] stressed the importance of the draftsman, who as a designer doing creative work was in fact an engineer. Any plan for his training, therefore, was of particular interest to the Society and deserving of its commendation. He questioned, however, if the plan as outlined would not defeat its purpose by turning out men qualified for positions which offered better inducements than the drafting board. Owing to the low salary paid, experienced men were constantly becoming discontented and drifting away from the board, in fact, out of engineering altogether. This was particularly true of the college man, who was of course inexperienced when he entered the drafting room, and generally contented to remain there for only a short time. The resulting percentage of unskilled men certainly called for some program to be provided for their training, and the plan described was evidently successful in that it helped men to quickly find the work they were best fitted for, as in the instances cited of the two who became a machinist and sub-foreman, respectively.

H. S. Hall[10] emphasized the importance of standardizing the technique of apprentice training and securing leaders who possessed that technique.

Chairman Jackson[11] expressed the idea that good apprenticeship training would tend to lift men to higher positions and that industry would rejoice and the apprentices become more enthusiastic.

C. J. Freund[12] stated that there were many organizations interested in apprentice training and that in many cases they were duplicating each other's work and required many reports on the same point. He suggested that the Society help to apportion this work so that each organization would accomplish more in a particular field.

The author, in closing, wrote that in the discussion contributed by Mr. Conant, in disagreeing with the idea that time was wasted by repetitive practice, he desired to point out that the degree of repetition of work as a means of securing required skills, would of course be determined when fixing the time elements as listed upon the charted course for a given checking level of type jobs, based primarily in accordance with the progressive demands upon skill as required for the work of the next checking level. An analysis of type jobs throughout any course would disclose that many of the operating elements of equipment and motions of the trainer would be repeated a countless number of times throughout the succeeding levels. Progressive growth in skills, he wrote, ran concurrently with a progressive growth in the other factors.

He did not anticipate the degree of credulity in our industrial field mentioned by Mr. Goss. This attitude would, however, have an undoubted value as an antidote to that of supervision through heterogeneous councils and committees lacking experience or technique of this work. It would at least accept that the problem was a technical problem. Mr. Goss, it would seem, had misread the paper, as it specifically insisted upon his point that regularity of instruction must be guaranteed.

[3] See charted course, Bulletin No. 52, Trade and Industrial Series No. 13, Federal Board for Vocational Education.

[4] Consulting Engineer, Washington, D. C. Mem. A.S.M.E.

[5] Supervisor of Apprentices, Brown & Sharpe Mfg. Co., Providence, R. I.

[6] Supervisor of Apprentices, N.Y.C.R.R., New York, N. Y.

[7] Engineering Director, Newport News Shipbuilding & Dry Dock Co., Newport News, Va. Mem. A.S.M.E.

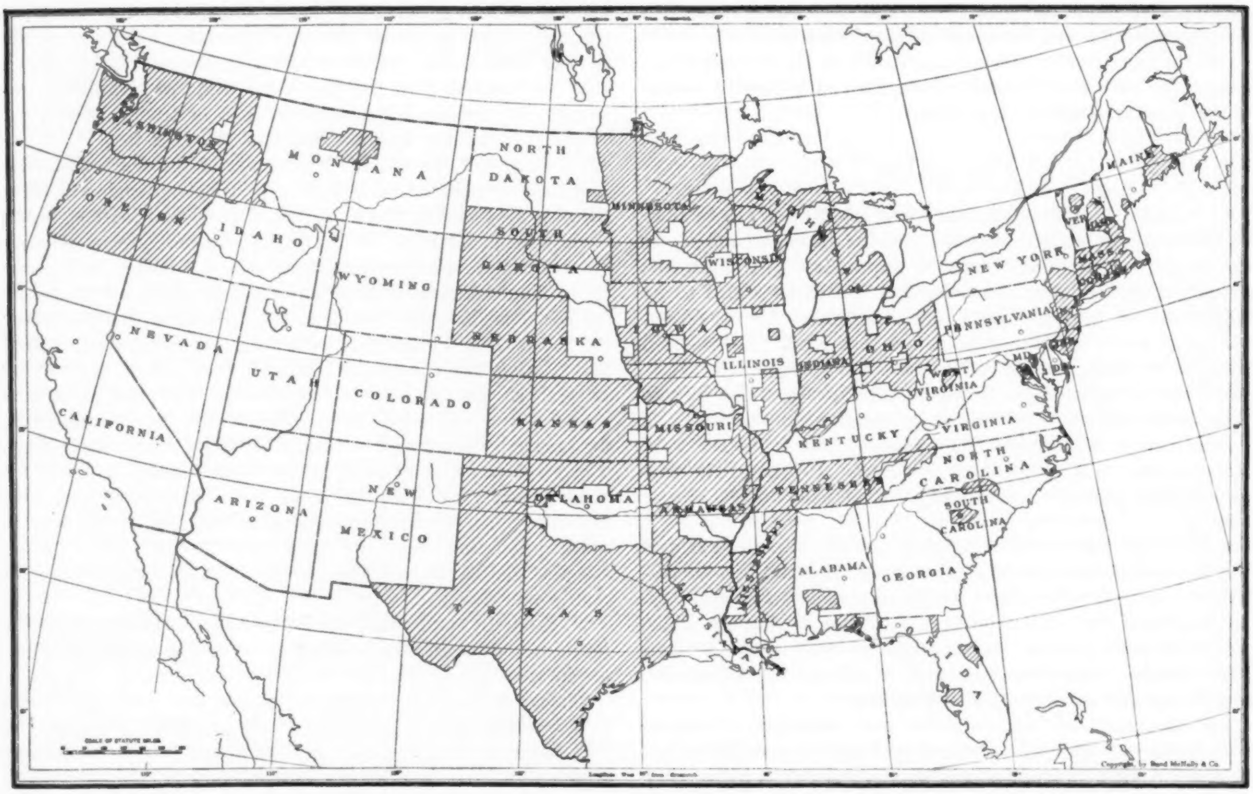
[8] State Department of Education, Albany, N. Y.

[9] Engineer, E. L. Phillips & Co., New York, N. Y. Mem. A.S.M.E.

[10] Director, State Trade School, New Britain, Conn. Assoc-Mem. A.S.M.E.

[11] Dugald C. Jackson, Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. Mem. A.S.M.E.

[12] Apprentice Supervisor, Falk Corporation, Milwaukee, Wis. Assoc-Mem. A.S.M.E.



A Cooperative Effort Against Fire Loss

Good Progress Reported in Acceptance of National American Standard Fire-Hose Coupling Screw Thread Throughout the United States

AT A RECENT conference of the manufacturers and distributers of fire-hose couplings called by the A.S.M.E. Standardization Committee, it was pointed out that within a comparatively few years approximately 50 per cent of the protected cities and towns in this country have adopted the National American Standard Fire-Hose-Coupling Screw Thread.[1]

The shaded portions of the accompanying map of the United States indicate the counties and municipalities in each state which have converted their fire-fighting equipment to the National Standard and are now enjoying the protection in times of emergency which the general adoption of this standard provides. Of the forty-eight states in the Union thirty are now or have been actively engaged in the rethreading program. Several of these have enacted laws making it a misdemeanor to use other than standard threads, while other states have encouraged the adoption of the standard through the activities of their various departments and the insurance companies but without legislation.

This progress is in a very large measure due to the activity of the National Board of Fire Underwriters.

[1] Three pamphlets have been prepared which describe this standard in detail and give supplementary information of value to the manufacturers and users of fire-hose couplings and hydrant outlets. These pamphlets are known as (1) "National American Standard Fire-Hose-Coupling Screw Thread," (2) "Production of National Standard Fire-Hose Threads," and (3) "Field Inspection of National Standard Fire-Hose Threads." All three may be obtained on application to THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 West 39th Street, New York, N. Y.

Since 1920 this organization through its numerous branch offices and connections has been in complete charge of the promulgation of this standard. This Board has also kept the progress records on this activity.

With the completion of the work in the northwestern, central, and northeastern states, the program is being extended to the southeastern sections of the country, which are now showing interest in the progress already made by the other states. It was pointed out at the conference that, should the activity be as successful as that of the past eight years, the remaining territory, except the large cities, will be fairly well standardized within the next five years.

EARLY DEMONSTRATION OF NEED FOR UNIFORMITY

The great need of uniformity in the interchangeable parts of fire-hose-coupling threads was demonstrated as early as the Boston Fire of 1872, and again during conflagrations in Baltimore in 1904 and in Augusta in 1916. At those disastrous fires, efficient fire-fighting apparatus sent from neighboring towns and cities were practically worthless because dissimilar hose couplings made it impossible to connect them to the hydrants or with the hose lines of the burning city. A similar difficulty is being experienced even now in many parts of the country when one fire department attempts to assist that from a neighboring town or city.

On the other hand, during the recent fire at Fall River, Mass., standardized equipment was used. Eighteen cities responded

to the call for aid by sending twenty-nine pieces of apparatus. Of these, all except one were able to connect readily to the hydrants or the hose lines without the use of adapters. As a result of this effective cooperation the fire, which threatened to destroy the entire city, was brought under control after the destruction of but parts of six blocks.

The use of motorized fire-fighting equipment during recent years has shortened the time involved in traveling from city to city, and outside aid can thus be had from considerable distances within a short time. In this way communities which have adopted the standard hose thread are given protection which could not otherwise be obtained.

The Early Steps

With the installation of water works throughout our country local attempts at standardization of hydrant outlets have been made from time to time, but it was not until reports of committees of the National Fire Protection Association and the American Water Works Association were received and adopted in 1905 that a serious attempt to establish a national standard was begun. These reports defined a proposed "National Standard" which was the best compromise between the several standards for fire-hose threads then in use. The International Association of Fire Engineers which had advocated this move as far back as 1875 adopted this standard in the fall of 1905, and confirmed this action in 1906. In 1923–5 the manufacturing limits of the coupling screw threads were set up and a complete set of limiting gage dimensions developed by a committee organized by the American Water Works Association, the National Board of Fire Underwriters, and The American Society of Mechanical Engineers. The standard was then presented to the American Engineering Standard Committee and received approval as an American Standard.

There are now in the United States about 8000 cities and towns having fire protection in the form of hydrants and fire hose. Approximately one-half of these already use the National American Standard Thread, and three-fourths of the remainder have threads that can be readily altered so as to be interchangeable with the National Standard. The remaining 10 or 15 per cent have fittings of such a type that the only practical method of standardization is to replace them entirely. Twenty-five of the protected cities included in the 4000 which have adopted the standards have populations of 100,000 and over.

For use in the cities where the existing threads can be readily altered, specially designed salvage tools have been developed by the National Board of Fire Underwriters, and experience with them in the field has shown conclusively that the resizing can be performed in a thoroughly satisfactory manner and at an expense per coupling ranging from nothing to thirty-five cents. Fire-insurance companies throughout the country have united in assisting in this standardization work. A set of these tools are loaned to the fire and water departments, and in most states an experienced engineer or mechanic demonstrates and instructs the men in their proper use.

The discussion which took place at the conference developed the fact that only 5 per cent of the non-standard cities and towns have a definite record of the thread which they are using. In some cities two sizes of threads were found, and in one city in New Jersey four sizes of threads were found to be in use. When new couplings are ordered by these non-standardized towns an old coupling is usually sent as a sample to the manufacturer. These threads when reproduced on the new coupling only serve to increase the present chaotic conditions, and explain to some extent the fact that at times couplings on the ends of the same piece of hose would not screw together, nor would they fit the hydrant outlets.

The task of converting fire-fighting equipment in the United States to the National American Standard through the initiative of the National Board has met with earnest cooperation during the past few years. Its value has been demonstrated and its importance is now receiving the worthwhile consideration which it justly deserves. It is to be hoped that our readers will consider the great advantages to be derived from the universal adoption of this standard, and will take part in hastening the coming of that glad day.

Eternal Vigilance Necessary

After standardization has been completed in a community, all new equipment, such as hydrant outlets, hose couplings, play pipes, and hose valves, must be ordered with threads to conform to the National American Standard. No samples should be sent. The new equipment must then be gaged by the purchaser when received. No equipment which fails to pass the gage tests should be accepted.

The official adoption of the National Standard and the resizing of existing equipment will not insure for all time the going together of the fire-hose fittings of the towns and cities of any community. This can only be accomplished by eternal vigilance, which begins with a careful inspection of all the threads of each and every new lot of fire hose and fire hydrants as they are delivered. It is perfectly obvious also that this inspection must be more than a casual examination of the threads and the screwing on of an old mating part to the new coupling or nipple. It is conceivable that such a procedure might accept new fire hose or fire hydrants which would not mate with half of the fire department's equipment.

Old couplings, hydrant nipples, or cast-iron hydrant caps are not reliable as test pieces or specimens, owing to wear and corrosion which they have experienced. Modern manufacturing processes call for the use of hardened steel models or final inspection gages by the manufacturers, and hardened steel models or field inspection gages by the persons responsible for accepting the equipment. It was not, however, until the nation-wide standardization program gained its present headway that the production of these hardened steel gages became economically possible.

At the March 16th conference of manufacturers and distributers of fire-hose couplings and similar apparatus, which was called by The American Society of Mechanical Engineers, it was decided to recommend that the standard set of field inspection gages consist of four pieces instead of six. These four are as follows: (1) "Go" plug thread gage, (2) "Go" ring thread gage, (3) "Not Go" plug thread gage, and (4) "Not Go" ring thread gage. All four of these gages should be non-adjustable. When applied to the threaded parts of a coupling the "Go" thread gages, both plug and ring, insure that all parts which pass this inspection will go together and will never be too tight. This test consists in screwing the gages on the parts being tested, covering the full length of the thread. The "Not Go" thread gages, on the other hand, are used to make sure that the parts will not produce a joint which is too loose. These gages should jam at about the second thread.

Among the encouraging developments at the Conference might be mentioned the report of one large manufacturer of couplings who stated that 55 per cent of his production was now on the National Standard. It is interesting to note also that gaging of the threads of fire-fighting equipment in the factories of the manufacturers was very thoroughly discussed. The Sectional Committee was asked to prepare a table of gage dimensions for manufacturers' gages and a list of recommended types of gages was prepared for the information of the manufacturers.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS (See also Marine Engineering: The British Aircraft Carrier "Courageous")

The Gloster IV

DESCRIPTION of a racing-type biplane equipped with a Napier Lion racing engine. It is of interest to note the considerations which led to the adoption of the biplane type of machine for racing purposes (last year's Schneider trophy race), and the following paragraphs are based on an article by the designer of the machine, H. P. Folland, in the Christmas number of the *Gloster Magazine*, the house organ of the builder company.

Can a biplane be as fast as a monoplane, given equal horsepower and the same design specification regarding performance? This is the question Mr. Folland asks in the article referred to. He then proceeds to outline the manner in which he and his assistants examined the problem. Comparison was made on three chief points: speed, wing rigidity, and application to service requirements.

Of these the first was the most important, and Mr. Folland states that what decided him was the fact that, with the "broad arrow" type of engine it was possible to fair the top wing into the cylinder blocks, to get all wires leaving the surfaces at large angles and thus reduce interference, to use a small-chord, thin-section bottom wing, the roots of which could, by curving them, be fitted into the fuselage with a minimum of interference, and finally by having surface radiators on both wings, to get a larger percentage of the radiators into the slipstream from the airscrew. From the structural point of view doubtless Mr. Folland was also influenced in his choice by the fact that torsional rigidity, or in other words guarding against wing flutter, is perhaps rather more easily achieved with a biplane structure than with a monoplane. Finally, although we doubt that it weighed very heavily in coming to a decision, it is to be remembered that the Gloster Company has had years of experience in building fast biplanes.

In the same number there is also an article by H. E. Preston, assistant chief engineer and designer, who points out that on the two items offering the greatest head resistance, the fuselage and the floats, a saving of 45 per cent as compared with the 1925 machine was effected by reducing the area and revising the lines—in other words, the *form*. Careful and smooth blending of the wings into the fuselage not only resulted in a reduction of the drag, but also gave an increase in lift of 15 per cent.

The article describes the constructional features of the machine in considerable detail. The wing construction of the Gloster IV is unusual in that the skin or covering is made part of the stress-bearing structure. Built up of laminations similar to those employed in the fuselage, the thin and almost symmetrical aerofoil sections used were formed by building up the skin on formers of the required contour and secured to the skeleton, which consisted of multi-spars, leading and trailing edges, and intermediate contour pieces in place of the usual ribs. On load tests the wings were found to support a load equivalent to thirteen times the weight of the machine before signs of failure were observed. Thus there was a good margin of safety in hand to take care of the increased acceleration possible in such a high-speed machine.

Mounted on the wings are the surface-type radiators specially developed by the Gloster Company. These radiators are made of thin corrugated copper sheets with waterways of brass at leading and trailing edges. Additional surface radiators are mounted on the decks of the floats, and as these are practically water cooled during prolonged taxying on the surface, they are very effective at a time when the engine is most likely to overheat.

The propeller is forged of duralumin and milled on a special machine to the correct contour and pitch. Thus no twisting of the metal is required and it is claimed that adequate stiffness and a minumim distortion under load are attained. The weight of the plane empty is 2300 lb., while the useful load is 710 lb. The wing loading is 23.2 lb. per sq. ft., and the power loading 3.44 lb. per hp. (*Flight*, vol. 20, no. 9/1001, Mar. 1, 1928, pp. 129–134, illustrated, *d*)

ENGINEERING MATERIALS (See also Mechanics: Bursting Pressures of Brass and Copper Pipe)

Mullite Refractories

THE mullite refractories (compare MECHANICAL ENGINEERING, vol. 48, no. 6, June, 1926, p. 633) are produced by a decomposition of sillimanite which is an aluminum-silicate mineral of the same class as andalusite and cyanite. Sillimanite is not stable, and all three of these minerals when heated to a sufficiently high temperature change into a substance of peculiar chemical composition which was named "mullite" from its occurrence on the Island of Mull. Of the three minerals sillimanite is nearest to mullite in its properties, and apparently differs from the latter largely because of the presence in it of small amounts of iron and titanium.

One of the most recent advances in the manufacture of mullite refractories is the casting of blocks and other shapes from the melted material. This is done by the Corning Glass Works. The mixture is melted at about 1900 deg. cent. in an electric-arc furnace and cast in molds made of glass sand and baked with a binder such as linseed oil. The cast blocks must be cooled slowly to prevent cracking. The blocks are laid without mortar, for they can be cast with flat faces which are so square and true that the seams are sufficiently tight. In fact, the blocks must be cast to desired dimensions since, because of their great hardness, chipping is impossible and grinding is expensive. The cast blocks are to be manufactured in a new plant built at Louisville, Ky., by the Corhart Refractories Co. recently incorporated by the Corning Glass Works and the Hartford Empire Company.

Mullite refractories can be used practically wherever fireclay refractories are used, but are capable of being subjected to more severe conditions. The full field for mullite refractories at present is in the glass industry, but they can be also used in enamel furnaces, as checkers in water-gas carburetors, and generally wherever high rigidity and freedom from shrinkage and spalling are worth paying the higher price for the material. (W. A. Koehler, Assistant Professor of Chemical Engineering, West Virginia University, in *Chemical and Metallurgical Engineering*, vol. 35, no. 2, Feb., 1928, pp. 86–88, *d*)

FUELS AND FIRING (See also Power-Plant Engineering: Powdered-Coal Burning in Lancashire Boilers)

The Carbonization Conference at Birmingham

THE Carbonization Conference held at Birmingham in the last week of February, 1928, was organized by the Joint Fuel Committee which represents several independent organizations. All the papers presented to the conference had already been presented to one or another of the organizations concerned with fuel problems.

The early portion of the conference was largely concerned with the relations between the coke industry and the gas industry. There are all signs of a keen competition between the two, both for the sale of gas and coke. Two papers were presented on modern coke-oven practice, and dealt with the new types of coke ovens that are being built by way of remodeling, at any rate partially, existing works, with, in some cases, the ultimate object of a larger installation to carbonize a greater amount of coal at a lower cost. In some instances entirely new plants have been built incorporating the latest labor-saving devices and features of design of the most modern American and continental plants. Practically all these new plants are constructed of high-grade silica brick, and are intended to be worked at higher temperatures than was the old practice. The greater output as compared with older types, which in some of the new projects exceeds a throughput of 1000 tons of coal daily, is one of the outstanding features of this new type.

Another feature is that the actual site of some of the larger plants is not at any particular colliery or even at a steel works, the deciding factor apparently being the suitability of the site for the central receipt of raw material from different sources and the disposal of large quantities of gas resulting from the daily carbonization of such large quantities of coal. It is the problem of the disposal of the coke and gas which is rapidly bringing the coke oven and ordinary gas and coke-supply industry into opposition, and there is an implied determination on the part of the former to compete with the latter if arrangements cannot be made for cooperative working.

A paper by Messrs. Greenfield and Harrison gave a considerable quantity of constructional detail in regard to modern coke-oven plants, and the two papers together were of a decidedly provocative nature in relation to the controversy between the two industries which is gradually getting keener. The point is that with the increasing size of plants, the problem of disposal of the gas and coke becomes positively embarrassing to the coke-oven industry, and these two papers indicate in their details of construction the reasons. As a matter of fact, a serious attempt is being made to form a technical committee to discuss the whole problem of cooperation between the coke-oven and gas industries, and the suggestion received universal support at the conference. There are several instances of the purchase of bulk supplies of coke-oven gas by gas undertakings in England, and the latest contract of this nature has been entered into at Sheffield. One of the stumbling blocks hitherto has been the question of continuity of supply of coke-oven gas. Recently, however, the coke-oven people have been more willing to give such a guarantee. The arrangement at Sheffield is that a very large stock of coal is to be maintained at the coke ovens, and in the case of a national coal stoppage it has been agreed to purchase coal from abroad or from any other possible source in order to maintain the supply of coke-oven gas. It has also been agreed that the men working on the plant shall be carefully chosen, men who are not particularly "red" or who would be prepared to join the Gas Workers' Union, or, it may be, are not union men at all.

Another paper of considerable importance, read on Wednesday, February 22, was by E. C. Evans, of the National Federation of Iron and Steel Manufacturers, and was evidence that a large sum of money has been and is being spent by the industry upon research. This work has been done by the Federation's Fuel Economy Committee under the chairmanship of Mr. Mannaberg, the object being to investigate the possibilities of increasing fuel efficiency in British iron and steel practice. That committee was appointed in 1923 and has done a considerable amount of work of a highly technical and detailed character relating to methods of testing, moisture, ash, distribution of coke ash, physical testing of coke, abradability of coke, reactivity, combustibility, and porosity. In this, assistance has been given by the Fuel Research Board and Prof. W. A. Bone, F.R.S., the latter in regard to blast-furnace reactions and the former on coke reactivity. Other work is being carried out on individual cokes by Dr. R. V. Wheeler and others. The various committees that have been formed throughout the country to develop this work are assisted by a grant in aid by the Department of Scientific and Industrial Research, and representatives of the Fuel Research Board and the Fuel Economy Committee of the National Federation have been appointed on all committees.

While Mr. Evans gave an outline of the investigations in hand, he states that as yet no definite conclusions can be drawn, but there appears every possibility that the researches in progress, whether of the fundamental character of those on coke reactivity and blast-furnace reactions, or of the more specialistic and empirical type by the various District Coke Research Committees, will, in the near future, be capable of definite correlation with results of operating practice, particulars of which are at present being collated by the Fuel Department of the National Federation of Iron and Steel Manufacturers. (*The Engineer*, vol. 145, nos. 3763 and 3764, Feb. 24 and Mar. 2, 1928, pp. 206 and 237–238, *g*)

HYDRAULIC ENGINEERING (See also Power-Plant Engineering: The Ohio River Plant of the Louisville Hydro Electric Company)

Pressures and Shape of the Jet in Standard Short Tube

THE standard short tube may be briefly described as one of the possible end connections between a pipe and a tank or reservoir from which it is drawing water. In ordinary work a pipe taking water from a reservoir may have its connection made with the tank in one of the following ways: (*a*) The end of the pipe may be cut off normal to the axis, and the pipe may be so placed that the inner end is flush with the inside of the reservoir; (*b*) the inner end of the pipe may spread out into a bell mouth, which is set flush with the inner reservoir wall; and (*c*) the end of the pipe may project some distance into the reservoir and may have either of the two forms of ends mentioned above. These several cases are illustrated in Fig. 1 at *a*, *b*, *c*, and *d*, respectively.

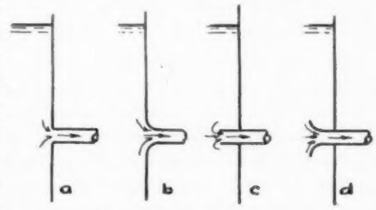


FIG. 1 VARIOUS TYPES OF TUBE AND TANK CONNECTIONS

The pipe laid in the first method is said to have a standard end, and contraction always occurs inside the pipe when water flows, this contraction being followed by expansion again till the water fills the pipe. That part of the pipe near the end, in which this contraction and expansion occurs, is called the

standard short tube, and its minimum length is from three to four times the diameter of the pipe. Some time ago the author of the paper investigated experimentally the conditions existing in this tube and the results of these experiments are given herewith.

The tube used had a diameter of 2 in. and a length of 8 in. and was screwed into the vertical flat end of a cylindrical drum 18 in. in diameter, the connection being so made that the inside of the head was a true plane, this surface being machined to make it smooth. The tube discharged into the atmosphere, the water then passing down into an orifice tank where it was measured. The orifice tank had a large cross-sectional area so as to avoid velocity of approach, and the head on the orifice was measured by a hook gage. The coefficients for the orifice used were obtained by direct measurements of the discharge in earlier experiments.

Outside of determining the discharge coefficient for the tube, the real purpose of the experiment was to measure the pressures at different points along its length, and afterward to use these pressures to compute the shape of the stream in the tube. Pressures were measured at four points on each of 51 planes located along the axis of the tube, these planes being $^1/_8$ in. apart in most cases, and somewhat further in others. All of the pressures inside of the tube were below the atmosphere and were read off a mercury manometer. The author gives the theory of the standard short tube, and an expression for pressure head and for loss of head in the entire tube.

The author then proceeds to calculate the velocity head in feet at various points as well as the limit diameters of the stream, the latter, of course, varying at various points along the axis of the tube. By careful adjustment the true shape of the jet may be very closely determined.

Between the tank and the vena contracta the losses would approach those in a sharp-edged orifice, and for such an orifice the coefficient of velocity at this total head of 48.5 ft. may be taken roughly as 0.98, so that for it the velocity head at the vena contracta will be $h_v = (0.98)^2h = 0.96 \times 48.5 = 46.6$ ft. Here h_v is velocity head in feet $= v^2/2g$ at a given section, and h is height of water in feet above the axis of the tube. The loss of head between the tank and vena contracta would therefore be $48.5 - 46.6 = 1.9$ ft. where the orifice was discharging freely into the air.

On the other hand, the loss due to the enlargement from the vena contracta to the end may be taken at 0.08 h_{v2}, as given in King's Handbook of Hydraulics, p. 181 (first edition), which would indicate a loss between the vena contracta and the discharge end of the tube of $0.08 \times 48.5 = 3.9$ ft. in one case and $0.08 \times 38.9 = 3.1$ ft. in another case. As the total loss in the tube is 9.6 ft., the result of these two calculations is too low. It would appear, however, that the greater part of the loss in the tube is between the vena contracta and the discharge end, and the diameter at the vena contracta has been taken as nearest that found by using the small value of h_{v1-2} and an effort has been made to adjust the diameter of the stream in accordance with the above discussion. The author, however, plots a number of points which are also given in a table and finds that these very clearly outline the curve.

The mean curve is quite definite in size and outline. The stream appears to be parallel for three inches of its length, which suggests that the tube might have been effective if it had been short, but a 2-in. $\times$ 6-in. tube did not work satisfactorily under a head of 28 ft. [Robt. W. Angus (Mem. A.S.M.E.), Professor of Mechanical Engineering, University of Toronto, in a paper published in the Engineering Research Bulletin of the University of Toronto, abstracted through *Power House*, vol. 22, no. 5, Mar. 5, 1928, pp. 39–31 and 45, 5 figs., 1 table, *etA*]

A New Law of the Flow of Water in an Open Channel

IN THE May-June, 1927, issue of *La Houille Blanche* the author published a paper in which he proposed a law on the flow of water in open channels based on experiments on two canals, one with a stony bottom and the other with walls lined with smooth cement. This law reads $V = K\sqrt{R}$, where V represents the velocity of a particle of water (velocity of which the horizontal component is the ordinary velocity U under consideration and the vertical component is V_1) and R is the average radius of a transverse section.

He now proceeds to apply the Reech law of similitude of ship hulls to the resultant V. Hitherto this law has been applied only to short bodies, and taking into consideration only the average velocity U, this means really only a single component of the velocity. It should therefore not be surprising to find the difference which the application of this law makes to bodies of considerable velocity when both components are taken into consideration. The Reech law was derived for the calculation of forces applicable to reduced-size models of ship hulls and is usually written $V_1/V_2 = \sqrt{L}$, where V_1 and V_2 are the velocities and L the ratio of homologous dimensions.

In the case of the hull shown in Fig. 2 the force is given by the

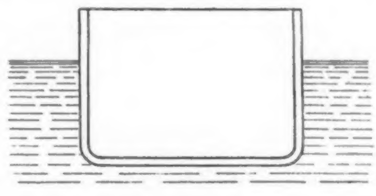


FIG. 2 DIAGRAM OF A HULL PARTLY IMMERSED IN AND FLOATING UPON WATER

equation of movement applied externally. If, however, one should build a very long hull with a slope I there will be an open channel in the interior of the hull. If, further, the walls are far apart and if for the moment no attention is paid to the variation of the coefficient C in the formula for open channels, then $RI = U^2$ and $U = C\sqrt{RI}$. Since U_1/U_2 is the ratio of average velocities for average radii R_1 and R_2, we shall have for a given slope the following expression:

$$\frac{U_1}{U_2} = \sqrt{L} = \sqrt{\frac{R_1}{R_2}}$$

But $U_1 = C\sqrt{R_1}\sqrt{I}$ and $U_2 = C\sqrt{R_2}\sqrt{I}$, hence the application of the Reech law to the horizontal component (the only one which has hitherto been usually considered) of the average velocity gives $\frac{U_1}{U_2} = \frac{C\sqrt{R_1}}{C\sqrt{R_2}}$, which means that C is a constant even when the radius varies, this being very far from the result found experimentally. On the other hand, the author computes the resultant V by the Reech law and finds in general that $V = K\sqrt{R}$, which shows that the expression given as experimentally obtained at the beginning of this abstract can be also obtained by applying the Reech law to the resultant V.

Influence of Slope I. For a given average radius R the application of Reech's law to the resultant V gives

$$\frac{V_1}{V_2} = \sqrt{\frac{I_1}{I_2}},\ V_2 = \frac{V_1\sqrt{I_2}}{\sqrt{I_1}},\ \text{or}\ V_2 = K\sqrt{I_2}.$$

By substituting $K = V_1/\sqrt{I}$, the general expression $V = K\sqrt{I}$ is obtained.

Bazin did not consider it worth while to make coefficient C dependent on the slope. He had observed its slight increase with the slope in the case of smooth-walled channels, but his experiments were made only with channels where R was greater than 0.30 m., and this prevented him from observing a clear variation of C. It is therefore possible to say approximately that $U = K\sqrt{I}$ and

$$\frac{U_1}{U_2} = \sqrt{\frac{I_1}{I_2}}$$

As a result of the similitude of triangles Fig. 3 gives

$$\frac{V_1}{V_2} = \frac{U_1}{U_2} = \sqrt{\frac{I_1}{I_2}}$$

or $V_1 = K\sqrt{I}$, where V_1 is the vertical component of the velocity.

On the other hand, the experiments of Ganguillet and Kutter have shown a quite noticeable variation of C, positive when the

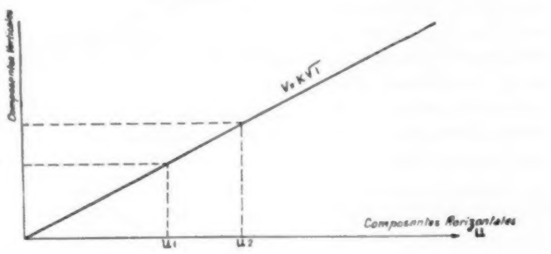


FIG. 3 DIAGRAM SHOWING THE COMPONENTS OF A VELOCITY

slope increased up to average radii of approximately 1 m. and negative for R greater than 1 m.

Fig. 4 shows the graphical results of the application of the Ganguillet and Kutter formula to slopes varying from 0.0001 to 0.001. From careful measurements it has been noted that in the case of large canals with smooth cement walls the Bazin formula gave excessively high results, and that it is necessary to employ not the coefficient $\gamma = 0.06$ of the first category but the coefficient $\gamma = 0.16$ of the second category. The difference may in part be due to the state of the wall, and as a matter of fact it is very possible that cement supposedly smooth under ordinary conditions may, in a large body, be much rougher than cement specially smoothed up for experimental purposes. The author does not believe, however, that the differences observed are entirely due to variation in roughness. He undertook to determine experimentally whether or not the anomalies found were due to the variation of transverse components which would cause the lack of exactness in the relation $V = K\sqrt{I}$.

The experiments made did not give conclusive results. To obtain such results it would be necessary to work on large canals of variable slope where the velocities would be quite variable for substantially the same volumes of flow, and furthermore it would have been necessary to make use of sufficiently large sections, in order to exclude at least partially the effect of the lateral walls on the magnitude of transverse components. Actually, however, in large industrial canals the velocities are substantially the same throughout. The experiments made by the author were carried out on canals of small average radii but large differences in slopes. In the article published in the May-June issue of 1927 the author stated that the principal cause of the existence of transverse components was the difference in the velocity of the liquid filaments. However, when the volume of flow of water is quite small and the slope is great, the value of the vertical component V_1 increases with increase of R instead of remaining substantially constant. It is very probable that in this case the ordinary effect of the difference of velocities is compounded and becomes preponderant over the turbulent movements directly created by the shock of particles of water against the rough spots of the wall. As R increases, the effect of the turbulent movements becomes relatively less important, and this hypothesis would appear to explain at least in part an observation made by Bazin who noticed in the case of small average radii, an increase of coefficient C with the slope but only where

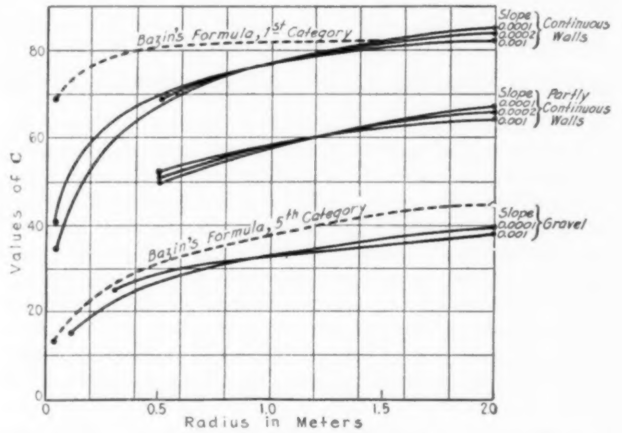


FIG. 4 GRAPHICALLY OBTAINED RESULTS FROM THE APPLICATION OF THE GANGUILLET AND KUTTER FORMULA TO VARIABLE SLOPES

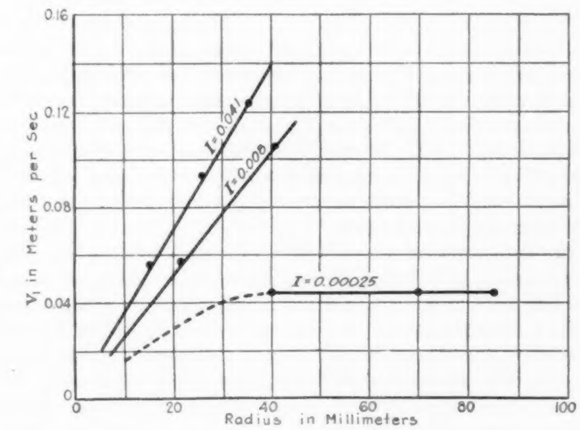


FIG. 5 VARIATION OF I WITH THE COMPONENT V_1 OF VELOCITY WITH CHANGES IN RADIUS

the walls were smooth, and found an opposite effect where the walls were rough.

In the author's latest experiments dealing with very small volumes of water the component V_1 was found to be very much below the value given by the formula $V_1 = K\sqrt{I}$. This is apparently due to the effect of penetration of the turbulent movement into the liquid filaments flowing at different velocities. Fig. 5 gives curves for $V_1 = f_{(R)}$ for slopes varying from $I = 0.00026$ to $I = 0.041$.

As a matter of fact, in the author's experiment he has been unable to find a case where both the slope and the volume of water flowing would be large enough in order to make the vertical component of velocity substantially constant, and the relation $V_1 = K\sqrt{I}$ does appear not to be essentially correct except in cases where differences of velocity are clearly prepon-

derant. The author proceeds then to a theoretical study of the differences of velocities in the vertical plane in canals of indefinite magnitude, and finds an expression for the distribution of velocities in the vertical plane, which is a curve approaching in shape a parabola of the second degree.

He refers next to the theoretical investigations carried out in this connection by Bazin.

The part dealing with the application of his formula to canals with smooth cement walls may be of interest. (M. Montagne in *La Houille Blanche*, vol. 26, no. 131–132, Nov.-Dec., 1927, pp. 172–176, *t*)

INTERNAL-COMBUSTION ENGINEERING

Buda Full-Diesel Engines for Industrial and Marine Fields

THE Buda engine is similar to the German M.A.N. and has been merely adapted to American standards and somewhat simplified. The engine is rated at 92 hp. at 1000 r.p.m. It is a four-stroke-cycle solid-injection full-Diseel unit with a bore of 6 in. and a stroke of 8 in. The engine is of en-bloc construction with a fuel pump mounted on the same side at the intake and exhaust manifolds nearest the end which would normally be the front of the unit. The crankcase and cylinder housing are cast integrally for any number of cylinders. The cylinder liners are made of gray iron and are readily removable, which is somewhat new in small engines. The inlet and exhaust valves are in the cylinder head. The inlet valve has a deflector on the head, which with the angular direction of the two opposed horizontal fuel sprays produced the turbulence necessary for the complete intermixture of air and fuel.

The fuel system consists of a cam-actuated plunger pump, with a plunger and cut-off valve for each engine cylinder which receive their impulse from the drive cams through tappet levers interposed between the main camshafts and the plungers. The cut-off valve can be adjusted by the same method used when adjusting ordinary valve tappets. The pump is mounted on a bracket integral with the crankcase and is driven off the timing-gear train. It is an unusually compact unit, the moving parts being enclosed in a common housing and operated by one drive-shaft having integral cams.

The spray nozzles are also of very simple construction, two of them being provided in each cylinder. The nozzles are placed in a horizontal position and are mounted so that the spray clouds assist during the period of injection in creating the turbulence which is also set up by the deflector on the inlet valve mentioned above. The nozzles are interchangeable, and are as easily removed and cleaned as spark plugs. However, cleaning is very seldom necessary as the fuel oil is filtered through a metallic gauze before entering the fuel pump. This virtually eliminates any possibility of the nozzles' clogging.

The governor is built into the fuel pump housing and controls the engine speed by operating the cut-off valves.

A unit of this type was installed on a 50-hp. truck in a four-ton chassis, and the original article gives data of performance as compared with the gasoline-engine truck. It is claimed that the truck not only gave greater economy but proved to be easier to operate. Contrary to general belief, the cooling of this Diesel engine was far easier than was that of the $4^1/_2 \times 6$-in. four-cylinder gasoline engine. The same radiator was used for both Diesel and gasoline engines, and during the summer months the water never heated sufficiently to raise the temperature so that the red fluid would come up to the average running mark on the motometer. When cool weather began, it was found necessary to provide the radiator with a shutter to keep the engine temperature suitable for good operation. (R. J. Broege, Chief Engineer, Diesel Division, Buda Co., in a paper before the S.A.E. meeting in Detroit. Compare with article in *Oil Engine Power*, vol. 6, no. 3, March, 1928, pp. 173–178. illustr., *d*)

IRON AND STEEL

The Oblique Rolling of Seamless Tubes

IN CONNECTION with a paper on a similar subject listed for presentation at the Spring Meeting of the A.S.M.E. in Pittsburgh, the following discussion may be of interest. This discussion is partly original and partly based on the report made last winter by Dr.-Eng. Fritz Kocks of Düsseldorf to the Rolling Committee of the German Iron Masters Association (Report No. 47). Dr. Kocks distinguishes three stages in the oblique rolling process as effected by doubly conical rolls. In the first stage the bar is gripped by the two rolls at a part at which the diameter is increasing; the hot metal bar is compressed more and more, turning at the same time, and is worn down internally. In the second stage the mandrel enters the hole formed—the end of the bar may be initially pierced to facilitate this—and work is put in the bar between the rolls, now decreasing in diameter, and the mandrel. The third-stage rolling between the cylindrical portion of the rolls is of the usual kind, so that only the first two stages need to be considered. The driving forces are the turning moments imparted to the rolls, but the external turning moments at any particular part of the roll cannot be calculated or measured as they could be with cylindrical rolls, because with the varying diameter of the specific pressures, contact areas, surface conditions, etc., are continuously changing.

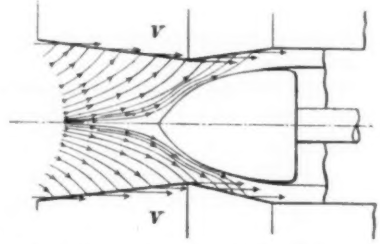
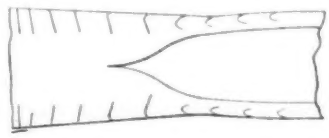


Fig. 6 Stress and Flow-Distribution Diagram



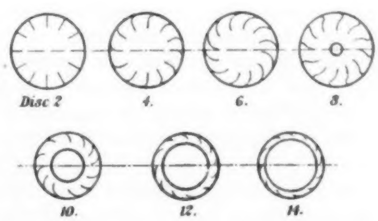


Fig. 7 Diagram Showing Curving of Previously Straight Radial Metal Crystals Formed in the Solidifying Billet

Fig. 8 Sequence of Changes in the Skin and Core Material in a Billet During the Piercing Process

The process can work satisfactorily only if the actual cross-section and the rate of advance are so adjusted that their product remains constant; otherwise the tube would be torn apart at some spot or another. The rolls are made conical for that reason, and are not merely mounted obliquely. The preheating of the bar to about 1300 deg. cent. (2372 deg. fahr.) that is, to a temperature far above the Ar_3 point, is indispensable. When the bar is fed in too cold, the pressure K is too great compared with the component K_v opposing advance, and the bar is not gripped but jerked back. This would also occur if the taper were too great. The use of the tapers introduces certain undesirable effects. Owing to the increasing diameter of the roll the rotational speeds of successive cross-sections of the bar tend to increase, in spite of slip between the parts, and torsional stresses

are set up. This torsion is not, as Gruber assumed, essential to the formation of the hole, but is an unfortunate incidental feature, though not of the importance that has been attached to it. Kocks actually measured a twist of 80 deg., while Gruber's deduction seemed to suggest something like 800 deg., which would be hardly possible for steel bars. In reality the rotational speed of the bar accommodates itself to a mean value. So long as the oval formation proceeds, the bar is rotating faster than the roll, but friction tends to keep the surface of the bar back. As the pressure and the contact areas grow, the bar and rolls will come into step. The formation of the hole begins as soon as the rate of the reduction of the thickness of the sleeve exceeds that of the reduction of the distance between the rolls. Once the hole has started, the actual pressure will diminish, and likewise the speed of the surface of the bar. Thus the surface layers of the bar will be exposed to stresses of varying intensity and direction, and any faults in the material near the surface, due to blowholes, cracks, slag inclusions, etc., are more likely to be further developed than to be cured, while the torn material in the bore will be welded up again by the rolling. These points are clearly brought out by Dr. Kocks' investigations and the illustrations he has published, some of which are reproduced.

As the bar remains hot in the interior while the outside is cooled by radiation and by contact with the cold rolls, the interior will be more easily deformed. Kocks observed with an optical pyrometer that the inside of the rolled tube was at 1360 deg. cent. (2480 deg. fahr.) when the outside had cooled down to 1230 (2246) deg.; the difference, however, is not always so great. The high internal temperature and the low strength of the core suggest the possibility of a stress and flow distribution as indicated in the diagram, Fig. 6, which accords with other considerations. The inner fibers of the bar are first pressed forward and outward. As the thinning and rolling proceed, however, the straight radial metal crystals which were formed in the solidifying billet become curved, as indicated in Fig. 7, because the skin and the core material are moving at different rates, and passing through the sequence of changes further shown in Fig. 8. (*Engineering*, vol. 125, no. 3242, March 2, 1928, pp. 269-272, 22 figs., *te*)

MACHINE SHOP

Finishing the Ways on Shallow Castings by Grinding

WHILE machinery for shallow work has been on the market for a number of years in the "traversing work" way grinder, a suitable machine for dealing with work of considerable height has not been immediately available. The problem is not exactly simple, and the first way grinder built for this purpose was rather crude and yet a high degree of accuracy has been obtained from the machine. This, however, was largely due to the uses of skilled operators who, being familiar with the weak points, of the machine, could make up for them by compensating for errors.

In the up-to-date type of grinding machine such as shown in the original article this has been taken care of. The machine is furnished with a radial arm rigid enough to admit of no deflection that is particularly noticeable even with grinder head in the extreme position. The grinder is provided with two grinding heads which can be put to work at the same time, thus doubling production. All the refinements of way grinding, such as systems of very sensitive spirit levels for setting heads to accurate angles, important in synchronous working with several heads and in obtaining interchangeable angle work, are incorporated. The operator rides on the platform from which he can control the heads with ease and all levers, handwheels, etc., for elevating the radial, starting, stopping, etc., are within his reach, independent of the height of the work.

One difficulty faced the designer in creating the "traversing head" machine and that was the counterbalancing of the heavy radial that carries the grinder heads. Whereas in the traversing-work type of machine this radial can without much difficulty be exactly counterbalanced by weight, this method was not permissible in the traversing-head type since at best it would involve the constant transportation of a heavy weight. A good solution of the problem was found in the hydraulic pressure, and by an ingenious and fully automatic system of balancing the load of the heavy radial is taken off the elevating screw—which is the feed screw at the same time—thus insuring the highest precision from this part of the mechanism. This coupled with the high-precision direct-motorized wheel heads as well as the other features of the machinery make it possible to obtain the extraordinary degree of accuracy which in the late-type machine having a grinding length of 20 ft. is within 0.0004 in. over its entire range.

By judicious means it is thus possible to eliminate all errors which deflection or play introduce and would otherwise defeat the object, which is to generate surfaces so true and angles so accurate that they will interchangeably mate. This object has been fully attained and further progress thus made by the abrasive wheel. (*Iron Trade Review*, vol. 82, no. 11, Mar. 15, 1928, pp. 685-686, 3 figs., *dp*)

MARINE ENGINEERING

The British Aircraft Carrier "Courageous"

IN THE April, 1928, issue of MECHANICAL ENGINEERING, pp. 280-285, were described some of the features of the American aircraft carriers, *Saratoga* and *Lexington*. Because of this, such information as may be available concerning similar British ships becomes of interest.

The British Emergency War Program included a number of large light cruisers built to designs formulated by Lord Fisher in 1915 and intended for operations in the Baltic. Among these were the *Courageous* and her sister ship the *Glorious*, both designed with fine lines and a shallow draft. A third vessel, the *Furious*, was built in a slightly modified type. The Baltic operations were never carried out, and it is understood that on her trials the *Courageous* strained her hull forward in heavy weather and had to be strengthened. Similar reinforcement was subsequently applied to the *Glorious*. As light battle cruisers these two vessels were only once in action during the war, and it is stated that on that occasion their protection, confined to a 3-in. plate, proved insufficient to resist the attack of the guns of light cruisers. Their limited number of big guns made effective salvo firing impossible.

The *Furious* was rebuilt as an aircraft carrier almost as soon as she was completed, and in that capacity was used in the air raid against the German airship sheds at Tondern.

After the war she was refitted, which operation included the removal of her funnel and mast and the incorporation in her structure of arrangements for discharging smoke through vents at the after end or alternately in the flight deck.

Both the *Courageous* and the *Glorious* have now been converted into aircraft carriers. The use of a funnel for the discharge of the smoke has been reintroduced in the case of the *Courageous*. The work of converting this vessel is estimated to have cost £2,025,000. It is stated that she will be capable of accommodating six flights of airplanes in her hangars. The *Glorious* has still to be completed, and is said to have a different layout from the *Courageous*.

The *Courageous* has an overall length of 786 ft. 3 in., a beam, over the bulges, of 81 ft., and a maximum draft of 26 ft. The normal displacement is about 18,600 tons, while that when fully loaded is about 22,700 tons. She is propelled by Parsons geared

turbines designed to develop 90,000 shaft hp., and driving four propellers. On trial as a cruiser, the horsepower developed was 93,780 and the mean speed was 31.58 knots. Steam is supplied by 18 boilers of the Yarrow small-tube type, equipped for burning oil fuel only. The armament carried comprises sixteen 4.7-in. guns and eighteen smaller guns; the positions of most of the 4.7-in. guns can be seen in an illustration in the original article, but it should be mentioned that there are two additional guns on the main deck aft, firing astern, similarly disposed to those shown mounted forward and firing ahead. The armor generally is on light-cruiser lines, a 3-in. belt being provided amidships, built up of 2-in. plating on 1-in. shell plating. Modified bulges are provided for protection against torpedo attack. It is understood that five flights of airplanes will be carried, comprising two fighter flights, one spotter flight, one spotter-reconnaissance flight, and one torpedo flight.

The other aircraft carriers of the British Navy are the *Hermes*, a vessel begun in 1917 and designed from the outset as an aircraft carrier; the *Eagle*, begun in 1913 by Armstrong's as a "Dreadnought" battleship; the *Almirante Cochrane*, built for the Chilean Navy and taken over and converted in 1917; and the Argus, begun in 1914 by Beardmore's as the Italian Lloyd Sabaudo liner *Conte Rosso*, and purchased for conversion in 1916. Mention may also be made of the cruiser *Vindictive*. This vessel was begun in 1916 as the *Cavendish*, but was renamed and completed in 1918 as an aircraft carrier. During 1923–25 she was reconverted to a cruiser, but she still retains an airplane hangar and a launching catapult forward. She is therefore something of a cross between a cruiser and an aircraft carrier. (*Engineering*, vol. 125, no. 3242, Mar. 2, 1928, p. 257. 1 fig., and *The Engineer*, vol. 145, no. 3764, Mar. 2, 1928, p. 230, 1 fig., *dg*)

Salvage of the S.S. "Nagara"

IN VIEW of the interest aroused recently by the salvage operation on the submarine *S-4*, the following information dealing with a similar operation on the twin-screw steamer *Nagara* may be of interest.

The *Nagara* belonged to the Royal Mail Steam Packet Meat Transports, Ltd., and is rated at a gross tonnage of 8803. On September 28, 1927, she came into collision off the Argentine coast with another steamer of approximately the same size. The *Nagara* was struck on the starboard quarter in No. 3 hold just forward of the bridge, and a large vertical rent was made. No. 3 hold was at once flooded and the ship in a couple of hours settled down on the bottom, the water being shallow enough to prevent complete submersion. Communication was established with Buenos Aires and by midnight of September 30, i.e., within about 48 hours after the collision, lighters and tugs had arrived and the discharge of water commenced, the tugs supplying steam to the salvage pumps. The underwater holes were plugged as far as possible by a diver, and by increasing the number of pumps drawing from the engine room the steamer was refloated at 4 p.m. on October 5.

For the last few days of operation the weather had been very troublesome, recurring changes in wind necessitating a constant shifting of the lighters and tugs from one side of the ship to the other as it was impossible to work to windward.

After a good deal of trouble due to this, steam connection was made to the ship's own pumps and the ship was towed to La Plata.

Subsequent to this repairs of a sufficiently permanent character were carried out to enable the ship to return to England under its own power. These will not be described here because of lack of space. (*Engineering*, vol. 125, no. 3239, Feb. 10, 1928, pp. 163–175, 7 figs., *d*)

MECHANICS

Bursting Pressures of Brass and Copper Pipe

THE chart reproduced here is calculated from a recognized equation known as Barlow's formula, and may be used with safety for obtaining approximately correct bursting pressures of tubes.

The formula may be used for practical conditions where the atmosphere is the external pressure or where the external pressure is moderately greater. In this case the difference between the inside and outside pressures represents the bursting pressure being exerted. It is assumed that gage pressures are referred to, and also that the tube is longer than its diameter.

Barlow's formula makes use of half the outside diameter of the tube for the radius. Results obtained by using such figures,

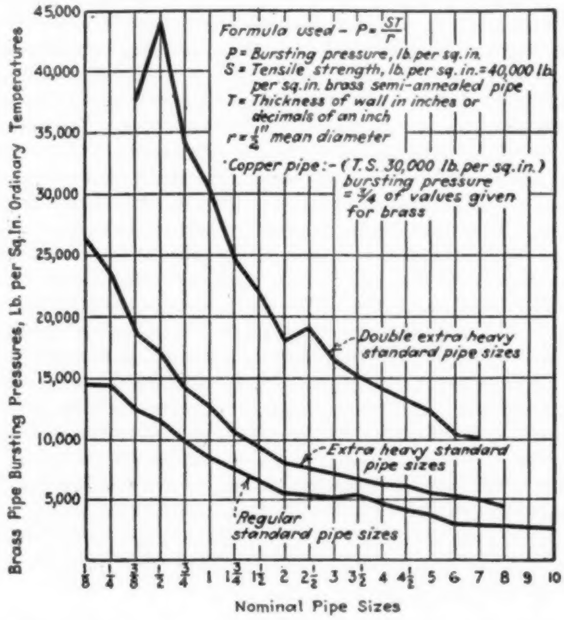


FIG. 9 BURSTING PRESSURES FOR STANDARD SIZES OF BRASS PIPE

it is felt, err too much on the side of safety, and therefore the chart has been calculated using as the radius one-half of the outside plus inside diameter divided by two, thus giving the mean diameter. A comparison between results obtained by using the two different radii shows an almost negligible difference in the larger pipe sizes. However, in the case of the smaller, the pressure obtained by use of the outside diameter may be 15 per cent below that using the mean. (Wm. G. Schneider, Copper and Brass Research Association, New York, in *Chemical and Metallurgical Engineering*, vol. 35, no. 2, Feb., 1928, p. 104, 1 fig., *p*)

Curved Beams and Crane Hooks

WHILE the paper here abstracted is more than ten years old, it is of interest because of the recent presentation of a paper on "Cargo Cranes" by B. Dunell before the Seattle Meeting, Aug. 29–31, 1927, of The American Society of Mechanical Engineers. The problem of the state of stress in a curved beam under load such as represented by crane and coupling hooks has been attacked by Winkler, and later by E. S. Andrews and Karl Pearson, the latter paper containing an account of prior work on this subject.

The present author claims that while the conclusions arrived at indicate that the curvature of a beam when considerable

cannot be neglected without serious error, the values of the stress arrived at by previous investigators do not satisfy the conditions of the problem in a satisfactory manner. The author considers first the effect of a pure bending moment applied to a uniform curved narrow beam having a shape of central plane and axis of curvature as shown in the original article. He finds that in such a beam in addition to the circumferential stress p, there is a radial stress p' which bears a considerable ratio to the circumferential stress. The value of this stress which is zero at the inner and outer surfaces of the beam reaches a maximum value at the ratios given by a somewhat complicated equation in the original article. The author points out further that the sign of p' is always the same, depending upon the sense of the bending moment M.

He shows that further if the beam is of such material as mild steel it will yield upon the occurrence of a particular shear stress, and proceeds to give an expression for the maximum shear stress at any point. The shear stress and the circumferential stress reach a maximum together.

With regard to the perpendicular shear stress due to the radial stress, it is to be observed that, since the maximum value of the radial stress p' occurs simultaneously with zero shear stress in the p-p' planes, this value of radial stress is equal to the value of the circumferential stress at the point, and hence is less than the maximum value of the circumferential stress.

Hence a curved beam of ductile material yields when the circumferential stress at the inner radius reaches the tensional yield point as determined in the customary manner.

It is clearly seen, by considering the equilibrium of an element, or of a thin half-hoop, at the inner radius, that the radial stress is of the same nature (i.e., tension or compression) as the circumferential stress there, and the existence of the radial stress, together with some idea as to its magnitude, can be gleaned by this elementary consideration.

Thus the strength of a curved beam may be taken as being governed by the circumferential stress at the inner radius, though in the case of materials such as cast iron, which are particularly weak in tension, the stress at the outer radius is to be considered if that be in tension without alternation. If the curvature is considerable, however, even cast iron will fail by compression or by the implied shear stress—at the inner radius, as the stress is there so considerably greater than at the outer radius.

The effect of the curvature upon the strength of the beam is expressed by the value of a coefficient λ, and the author gives numerical values of this coefficient for a number of values of n, where n is the ratio of the stresses at the two boundaries (i.e., the stress at the nearest boundary divided by the stress at the farthest boundary).

From this the strength of a beam can be readily ascertained as the maximum stress may be calculated by multiplying the stress which would be produced by the moment if the beam were straight by $^1/_6$ of the λ coefficient. Curves are given for the circumferential and radial stresses arranged as percentages of the maximum circumferential stress occurring.

In the course of his discussion the author shows that the state of stress in a narrow beam of considerable curvature differs from that in a straight beam of similar section in the distribution of the circumferential or longitudinal stress, in its maximum value, and in the existence of a radial stress which becomes rapidly greater as the curvature increases. When the thickness increases other differences arise. As an illustration of his theory he considers several numerical examples. The following is quoted as part of his conclusion:

When a member of a structure of machine is bent so that it has a radius-corner and is subjected to forces such that cause, at a radial corner section, normal forces, shears, and bending moments, in general the stress due to the bending moment is so high compared with the stresses caused by the forces that the latter may be neglected. Considering the action of a pure bending moment on a part having a change of curvature, the stresses tend to increase with the curvature, but will not attain the magnitudes which they would have if the maximum curvature were continuous. Accordingly in corners an estimation of the maximum stress by the preceding method will be an overestimate of the actual amount, and the method may therefore be safely used for design.

In conclusion, the stresses produced by a bending moment in uniform curved beams of certain sections have been determined, and by means of the curves or tables given their amount in these cases can readily be ascertained. In the case of other sections, provided that they have no extraordinary features, a consideration of the results obtained shows that the shearing stress about the circumferential lines produces small effect upon the circumferential stresses, and in such cases the method of estimation given will afford a close approximation to the maximum stress produced by the bending moment. (James J. Guest, University College, London, in a reprint from *Proceedings of the Royal Society*, A, vol. 95, 1918, 21 pp., 5 figs., *mt*)

PAPER MILLS (See Power-Plant Engineering: Uses of Low-Pressure Steam in Paper Manufacture)

POWER-PLANT ENGINEERING

Powdered-Coal Burning in Lancashire Boilers

THIS is done in a large industrial plant in the Midlands, England. There are three boilers each measuring 8 ft. in diameter by 30 ft. in length. The boiler flue which is 3 ft. 3 in. in diameter, is attached to a conical extension about $3^1/_2$ ft. long which is lined with refractory tiling and has at the end a burner to admit the pulverized coal and air in a tangential direction so as to give it a spin. The boiler flue is lined for about 3 ft. of its length at the top with refractory tiling and for about 10 to 12 ft. of the length at the bottom. This with the conical extensions above mentioned provides a sufficiently large combustion chamber for the pulverized coal to be completely burned.

The air is preheated to about 180 deg. fahr., and means are taken to cool it by admission of cold air should its temperature rise higher than that specified. The mixture of coal (pulverized in an impact machine having beaters running inside ribbed linings of manganese steel) is ignited by a flame inserted through the tube in the center of the burner. The flame passes through the boiler flue in a spiral manner, the swirl gradually diminishing toward the rear end. This spiraling of the flame is an important feature, because it helps to remove the gases as they are formed around the carbon particles, and gives opportunity for free oxygen to combine with the carbon. The makers say that with medium-quality bituminous coal they have no difficulty in obtaining efficiencies of about 75 per cent with ordinary Lancashire boilers. Many Lancashire boilers give efficiencies of only 50 to 60 per cent when fired with lump coal by hand or by mechanical stokers, and then require a better grade of coal than can be used in pulverized form. (E. Kilburn Scott in *Combustion*, vol. 18, no. 2, Feb., 1928, pp. 106–107, 1 fig., *d*)

The Plant of the Consumers Company, Kalamazoo, Mich.

THE generating equipment consists of a 20,000-kw. bleeder-type three-phase 60-cycle turbo-generator. The turbine receives steam at 350 lb. gage and 725 deg. fahr. total temperature. It is a 14-stage impulse machine arranged for bleeding

from the fourth, seventh, and eleventh stages for furnishing steam to operate a make-up water evaporator and to heat the feedwater. The turbine exhausts into a two-pass surface condenser of 25,000 sq. ft. cooling surface, 23,500 sq. ft. of which is in the main condenser and 1500 sq. ft. in an external air cooler. The condenser is equipped with a set of steam ejectors which consists of two primary and two secondary jets together with inter- and after-condenser units for condensing the steam of the jets, condensate from the main unit being used for this purpose.

To assure deaeration of the condensate, the condenser is equipped with a special type of hotwell guaranteed to reduce the dissolved gases in the water below the danger point. In order that the make-up may also be free from oxygen and corrosive gases, special arrangement is made for taking the make-up water from an outside pure-water storage tank and spraying it into the top of the condenser. A surge tank is located in the top of the boiler room and is connected to the boiler-feed header. When the level in this tank falls below a safe working level, a float-controlled regulator opens a valve in the line from the storage tank to the condenser and make-up is drawn into the condenser by the vacuum. If the level in the surge tank rises nearly to the point of overflowing, the float-controlled mechanism opens a valve in a line joining the discharge of the condensate pumps with the outside storage, and some of the condensate is pumped into the outside tank.

The fourth stage of the turbine is bled to furnish steam for heating the feedwater in the high-pressure heater and for the evaporator. This heater, as well as the intermediate or seventh-stage heater, is of the floating-head closed type built for 150 lb. steam pressure and 600 lb. water pressure. The drips from this heater are trapped into the intermediate or seventh-stage heater.

The coal-pulverizing equipment consists of two four-ton-per-hour capacity Type 5-A Simplex unit pulverizers per boiler located on the boiler-room basement floor. The mills are driven by 440-volt 100-hp. constant-speed alternating-current motors operating at about 1150 r.p.m. The fans on the end of the mill shaft draw about 800 cu. ft. of air per min. through the mill and about 12,000 cu. ft. per min. from the hot-air duct, the two streams of air joining at the discharge of the mill and constituting the primary air supply to the burners. The primary air is from 35 to 70 per cent of the total air for combustion, depending upon the amount of coal being burned.

At the time of the design of the plant it was contemplated it would be possible to generate 1 kw-hr. with $1^1/_4$ lb. of good-quality coal, and the present results show that it will be easily possible to reach this figure. There are not the highest efficiencies as considered today, but for a plant of this size are very satisfactory results for the pressures and conditions that were adopted in the design. (J. W. MacKenzie and W. E. Jacobs, of the Consumers Power Co., Jackson, Mich., in *Electrical World*, vol. 91, no. 2, Jan. 14, 1928, pp. 87–93, illustr., *d*)

Uses of Low-Pressure Steam in Paper Manufacture

THE author claims that there are really very few plants working at a high degree of efficiency, but that there are many score which enjoy the bliss that comes from ignorance.

The outstanding examples, outside of the paper industry, are woolen mills finishing their own goods, and plants bleaching, dyeing, mercerizing, and finishing cotton piece goods. In all three of these industries high-pressure steam is used for some operations outside of mechanical power. Low-pressure steam is used for drying and ventilating, and sometimes boiling. Considerable quantities of hot water are required. Water must be pumped, compressed air may be needed, but all of these may be reduced to the simple B.t.u. which must in the last analysis be dug out of the coal pile.

A few years ago a young engineer connected with a paper mill read a paper before one of the meetings of The American Society of Mechanical Engineers in which he analyzed the power and heating requirements of a paper machine, and arrived at the conclusion that an engine which utilized 50 lb. of steam per hour per indicated horsepower would exhaust just enough steam to serve the subsequent purposes of the paper machine. Here is, according to the author, one of the most glaring examples of misapplied principle and misdirected effort. Had a source of mechanical power been used which utilized but 25 lb. of steam per hour per i.hp., sufficient power would have been developed to not only drive the paper machine but to drive another one like it, or some other machinery not utilizing low-pressure steam.

In a cotton-piece-goods finishing plant with which the author is familiar there are many small engines driving drying cylinders, printing machines, tenter frames, etc., the exhaust steam from these being delivered into a general main from which low-pressure steam is taken for drying and heating purposes. There is no evidence of any exhaust steam being discharged to the atmosphere, and the management believes that the so-called heat balance is nearly perfect. In the main engineroom of this plant there are large prime movers operating condensing, with at least 85 per cent of the heat of the steam being discharged with the condensing water. If this particular plant used prime movers ejecting 18 to 20 lb. of steam per hour per i.hp. and operated non-condensing, all of the mechanical power required would be generated with no heat to be discharged either to the atmosphere or through a condenser.

A well-balanced worsted mill finishing its own goods can develop all of the mechanical power required to run the entire plant, with a complete utilization of latent heat excepting that represented by radiation and stack losses.

The author next considers the way to study heat requirements of a plant, both as to the prime movers and the use of the steam.

As it is evidently desirable to obtain the greatest amount of mechanical power possible from a given amount of steam, we must consider types of prime movers and initial pressures. If we can get 50 per cent more mechanical work out of a turbine operating with an initial pressure of 350 lb. and an exhaust pressure of 5 lb. than we can from one with an initial pressure of 150 lb., we cannot afford to overlook that fact. In our design, whether for new construction or in reconstruction, we must bear in mind the ultimate, although we may have to sacrifice something temporarily. The same consideration must be given power-plant auxiliaries, choosing a type that will require the least amount of steam for the mechanical work performed, and we finally arrive at the amount of steam required at the boiler nozzle to manufacture so many tons, yards, or bushels of product.

The author does not belittle the importance of recent boiler designs, boiler settings, methods of firing, etc., but more stress has been laid upon this than upon the subsequent uses of steam, and it is his belief that for a given sum of money more can be accomplished between the boiler nozzle and the coal bin. Boiler efficiencies do not vary from day to day to any great extent and it is a comparatively simple matter to find out where faulty operation lies, but efficiency in the use of heat in the manufacturing end can and does vary rapidly, particularly when extensions or alterations are made. In some of the older plants where small engines are scattered about it is possible to realize 1 hp. from 70 lb. of steam, taking into consideration pipe-line losses, engine inefficiencies, etc., while with well-designed equipment it is possible to realize 1 hp. from 20 lb. of steam, or, to put it another way, 3.5 times as much mechanical power can be obtained from the same amount of steam taken from the boilers.

The writer is familiar with instances where it is possible to produce more mechanical power than can be used. In such a case the amount of low-pressure steam ejected from the prime mover in insufficient and live steam must be admitted. This is almost an ideal condition because with decreased production the balance is favorable, while with increased production live steam is admitted to the low-pressure system with no loss of heat.

Power which is not a by-product is in direct competition with public-utility power. In many sections of the country power can be purchased at a lower price than it can be manufactured on the premises when it is not a by-product, and frequently a combination of by-product with purchased power is highly economical.

To sum up, the writer emphasizes the following points:

1 Temporarily forget the mechanical power requirements and the boiler plant and study the uses of heat.

2 Every operation requiring heat should be done with low-pressure steam wherever possible.

3 Reduce the amount of low-pressure steam to a minimum through the study of machines and processes.

4 Adopt a type of prime mover that will give the greatest amount of mechanical power per pound of steam ejected.

5 Spend your money first on improving apparatus and piping systems, utilizing low-pressure steam before worrying about the boiler plant except for some other reason than efficiency of the latter. (Warren B. Lewis (Mem. A.S.M.E.), Cons. Engr., Providence, R. I., in *Paper Trade Journal*, vol. 86, no. 9, March 1, 1928, pp. 62–64 *g*)

The Ohio River Plant of the Louisville Hydro Electric Company

THIS plant, located at Shipping Port, just below Louisville, Ky., and built to generate 100,000 kw., is remarkable in that when completed it will be the largest automatically controlled hydroelectric station in the world. The present installation consists of eight 12,500-kva. vertical-shaft generators, and space is provided for two more similar units. It will be under the guidance of only two men—a supervisor and a floor attendant.

Among the unique features of the station is the electrical layout. The conventional switchboard has been entirely eliminated, and has been replaced by individual control panels installed in cabinets or "cubicles" alongside of each generator. Each cubicle contains relay mechanisms for starting, running, and stopping its generator, together with protective equipment for the following emergency conditions: generator field failure; a.c. overvoltage; low oil pressure in governor system; generator overspeed; overheated machine bearings; and ground fault in generator armature windings. In addition, a synchronism and voltage checking device makes it possible to connect a generator to its bus until electrical conditions are correct.

The cubicles are constructed of steel, and are provided with double glass doors, both front and rear, so that all devices and instruments may be seen without opening the cabinet. Connecting leads are brought up through small pits in the floor and are plugged into the proper terminals by means of multi-plug couplers. Pull-button switches are built into the front doors so that starting—the only operation which must be completed by the floor man—can be carried out with minimum delay.

In normal service the station is under the management of a supervisor, centrally located at his controlling cabinet. When the load demand increases, the supervisor indicates by means of a signal light on a generator cubicle that this machine is needed on the line. The floor attendant immediately operates the starting button on this cubicle, and the gate-operating mechanism is put in motion, bringing the generator up to speed. As soon as the machine is in rotation, the automatic control devices come into play and the incoming machine is placed on the bus as soon as its electrical conditions are correct. The supervisor then takes charge, manipulating the load to best advantage from his desk. By throwing a single switch in the cubicle all control operations may be made manual.

Certain local conditions had to be taken into consideration in the design. The extremely erratic behavior of the Ohio River produces a head of water on the station varying from zero to 37 ft. The high-water, low-head season lasts about three months of the year and during this time the station will be shut down. When the effective head has reached 9 ft. it is possible to carry a light load on the generators, and this load is increased until maximum head of 37 ft. permits the station to generate its full capacity. A peculiarity of the station is that there are no windows within 25 ft. of the generating-room floor, as the station is practically half under water during the flood season. (*Water Works*, vol. 67, no. 3, March, 1928, pp. 123–125, illustrated, *d*)

Automatic Control in a Czechoslovakian Plant

AT THE electric power station at Holeschowitz, near Prague, in Czechoslovakia, a plant at which the load is extremely variable, an interesting form of automatic control of the boilers devised by Roucka of Blansko, Moravia, has recently been adopted with, it is stated, excellent results.

In the case of variable loads it has been found that the efficiency of a boiler can be increased if the rate of combustion can be varied in accordance with the load, and it was to meet this requirement that the Roucka automatic arrangement was devised. It consists of a series of levers connected up to a servomotor which, by means of oil under pressure, operates the adjustment control apparatus. In the Roucka system the levers are constantly in a state of vibration, and are thus more ready to respond instantly to any movement than if they were entirely at rest. Altogether eight different controls are comprised in the system, as follows: (1) A combustion regulator which acts on the valve controlling the combustion gas passage; (2) a vacuum regulator in the furnace, which varies the amount of air entering below the grate; (3) a feedwater regulator controlled by a float which follows the level of water in the boiler, and (3) a fuel-feed regulator by means of which the steam generation is kept proportional to the quantity of air admitted. The various controls are electrically connected to a multimeter provided with measurement indicators and recorders. The four other proportions of the automatic control mechanism indicate the steam pressure, the degree of superheat, feedwater, temperature, and percentage of CO_2.

F. Karas, the engineer of the Holeschowitz power station, has recently drawn up a report on the working of the Roucka installation, a summary of which is appended. The load at this station is extremely variable. Thus in one month it varied daily between 2,000 and 32,500 kw. During the night it was necessary to shut down many of the boilers and to restart them during the day and periods of peak loads. The loss of heat due to these conditions may be estimated as representing 3 per cent in summer and 5 per cent in winter of the total coal consumption. As a result of the modernization of the plant a few years ago—by the installation of new boilers and the adoption of turbines—the heat units per kilowatt-hour fell to 33,000 B.t.u. This, however, was not equal to the anticipated economy, but even the installation of indicators showing the CO_2 content of the fuel and the establishment of a fuel laboratory did not result in any improvement. It was then decided as an experiment to fit three of the boilers with Roucka eight-indicator multimeters, the results of which were so satisfactory that the twelve new boilers, working at 220 lb. per sq. in., have since been fitted with similar apparatus and also the fourteen old boilers which de-

liver steam at approximately 185 lb. per sq. in. with triple indicator multimeters showing the quantity of air and steam and the temperature of the combustion gases. As a result of the automatic installation, the efficiency of the boilers has increased from 58.25 per cent to 70 per cent, while the heat units per kilowatt-hour have fallen from 33,000 to 27,000 B.t.u. Karas adds that the apparatus has worked well, although it needs constant supervision and requires to be tested at regular intervals. (Chas. J. Webb in *Power Plant Engineering*, vol. 32, no. 6, Mar. 15, 1928, p. 354, *d*)

RAILROAD ENGINEERING

The Silica Gel Iceless Refrigerator Car

THE Safety Car Heating and Light Co., New York, has had in service for a number of months a refrigerating car using vapor absorption by silica gel as the cooling medium. Silica gel is a hard, glassy material with the appearance of a clear quartz sand, and is obtained by a reaction involving so-called water glass. The remarkable part of it is that it is of an extremely porous character, the pores being so minute that they cannot be detected under a microscope and yet constituting over 40 per cent of the volume of the material.

The presence of these minute voids gives silica gel the ability to absorb relatively large quantities of vapors. As an example, a quantity of silica gel placed above water in a closed vessel will absorb or take up water vapor to the extent of 25 per cent of its own weight. If it is then removed from the vessel and activated by heating, the water vapor will be driven out and the silica gel rendered capable of absorbing more vapor. This action is purely physical, and the cycle may be repeated indefinitely, with no alteration in the structure of the silica gel or decrease in its absorptive power. It is this peculiar property of silica gel which forms the basis of the operation of this iceless refrigerator car.

The apparatus consists essentially of three main parts: namely, the absorber (containing the silica gel), the evaporator, and the condenser. It may be briefly described as being identical to a compression-type machine with a compressor replaced by the absorber, the absorption of the refrigerant vapor by the silica gel corresponding to the suction stroke of the compressor and the activation of the silica gel to the discharge stroke. No power need be generated for the silica gel system, the necessary heat being applied directly to the silica gel.

The operating cycle of the apparatus may be described as follows: Assuming that the silica gel in the absorber has been activated, it will absorb vapor from the refrigerant in the evaporator, causing a lowering of the temperature of the latter by the evaporation of the refrigerant. Evaporation of any refrigerant in the condenser is prevented by the float valve and the check valve in the vertical pipe.

When the silica gel has become saturated with vapor, it is heated by means of a gas burner and refrigerant vapor is driven out of the silica gel, passing to the condenser where it is liquefied and returned to the evaporator by the float valve. The horizontal check prevents the entrance of vapor to the evaporator. When activation of the silica gel has been completed, the source of heat is removed and, as soon as it has cooled sufficiently, the absorption phase begins automatically. In actual operation, the heating period is much shorter than the absorption period, and by dividing the absorber into two sections and heating them alternately, continuous refrigeration is produced. As actually constructed, the silica gel is contained in many tubes of small diameter to effect a rapid heating and cooling.

For purposes of controlling the temperature in the car a thermostat is used. When the car temperature falls to the point for which the thermostat has been set it interrupts the flow of gas to the timing device and thus suspends the operation of the apparatus.

In a test run made last December from New London, Conn., to Fort Worth, Texas, with a load of frozen haddock fillet, the temperature at no point in the car exceeded that for which the thermostat was set. The car was precooled to 2 deg. above zero before loading, and the temperature of the fish when loaded averaged 18 deg. fahr. It was unloaded at a temperature of 14 deg., having been in the car eleven days.

Pintsch compressed gas was used as a fuel. It was not necessary to refuel during the run, and only half of the initial charge was consumed. (*Railway Age*, vol. 84, no. 7, Feb. 18, 1928, pp. 406–408, illustrated, *d*)

REFRIGERATION (See Railway Engineering: the Silica Gel Iceless Refrigerator Car)

WELDING

Cutting Steel Under Water

REFERENCE was made to cutting steel under water in Mechanical Engineering, vol. 49, no. 3, p. 273. The present article describes the removal of the steel-plate bulkhead in front of a huge water intake made necessary in erecting the new Glenwood Power Station on Long Island Sound, New York. The equipment and materials used in this work consisted of an Ellsberg model S-51 underwater cutting torch, the same as supplied to the U.S. Navy for salvaging the *S-4* submarine, together with the various other equipment.

Due to extremely low temperature (the work began on Jan. 30, 1928) and rapid current, special precautions were necessary to enable the diver to operate. The work was made all the more difficult by the unusually severe atmospheric conditions. The specifications for the work were extremely rigid, requiring the cutting to be done on a line with the bottom on the intake with a tolerance of only 1 in., which necessitated the taking of levels for each cut.

The work consisted of cutting approximately 120 lineal ft. of Lackawanna steel sheet piling (arched-web sections), weighing 58 lb. per ft., including also four three-ply angle pieces and one three-ply tee. The piles were 40 ft. long, extending 15 ft. into the ground, 15 ft. through the water, and 10 ft. above water. They had been very carefully driven, and no filler of any kind had been used in the lock joints. When this work was begun, they had been in position for more than 18 months. The maximum thickness cut in the standard sheets was more than 2 in. (close to the locks), and in the tees and ells was only slightly less than that, but with cutting much more difficult because of the three-ply metal in the web. The depth of the "cut" below surface was approximately 15 ft.

A total of 57 hr., or the equivalent of about seven working days, was required to complete the work, the diver averaging five and one-half hours of actual diving time out of an eight-hour day, the remainder of the day being consumed in dressing and undressing and by the noon recess. (Chas. Kandel, Gen. Mgr., Craftsweld Equipment Corp., New York, in *Acetylene Journal*, vol. 29, no. 9, Mar., 1928, pp. 359–360, illustrated, *d*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Engineering and Industrial Standardization

Right Turn on Red!—Green! Which?

STREET signs, signals, and markings will be the same in all the cities of the United States, and confusion in traffic control will be wiped out if the recommendations of a Sectional Committee organized by the American Engineering Council under the procedure of the American Engineering Standards Committee, are finally accepted.

Working in cooperation with the Hoover Conference on Street and Highway Safety, the American Engineering Council Committee conducted a nation-wide survey, in which conditions in more than 100 cities, with a population in excess of 35,000,000, were exhaustively investigated. The state of New Jersey already has written part of these recommendations into a uniform state law now before the legislature, which, it is expected will be enacted during the present session.

Almost every motorist has had the experience of driving through several cities on a single day's trip, and finding different signal systems in each city. He has found that these different systems, with different light arrangements and in different locations at the crossings, have actually meant different things for the same color light. There are the green-yellow-red systems in which the yellow means that all traffic is to be halted and pedestrians are to go, in which a five-second cautionary or warning interval is indicated, in which only right- or left-hand turns can be made, or in which he will also have to wait for a bell to ring before proceeding further. Then when the green comes on he is doubtless as badly confused because when he wants to turn to the left in Washington he must first pull over to the right and wait for the light to change, whereas in the next large city he comes to, Baltimore for example, if he wishes to turn left on the green light he pulls over to the left-hand side of the street and weaves through oncoming traffic. His problem would be expected to be solved when the red light comes on, and he would doubtless stop, but in some places, like Atlantic City, red actually means "Go" for all who wish to turn to the right at intersections. In at least one other city he will find a single red light that will come on and demand that he stop; when he can proceed the red light simply goes off.

Who has not driven from city to city to find red, yellow, green, white, blue, and other colored signs in every conceivable shade used in traffic control. Shapes as numerous as colors and messages of greater variety and intent may be found on the signs. Pavement markings are less numerous in color and word arrangement and location, but they are nevertheless widely diversified in various cities.

The A.E.S.C. Sectional Committee aims to correct these unfortunate and dangerous conditions by recommending a comparatively few standards which, it is intended, shall be of great assistance to motorists, to municipal officials, and to manufacturers of the various products. In fact, the fundamentals of the program were established as an American standard some time ago by another A.E.S.C. committee which worked on the same problem. This standard established the exact meaning to be attached to red, green, and yellow. It is the minor details of their applications which are now occupying the attention of the Sectional Committee. This activity will result in a real public service if the recommendations can be carried into effect without great delay.

The work of this Sectional Committee on Street Signs, Signals, and Markings under the sponsorship of the American Engineering Council, has been headed by W. B. Powell, of Buffalo, N. Y., former traffic engineer of Baltimore, who served as chairman, and A. C. Oliphant, of Washington, as executive secretary.

How Hazardous Is Spray Coating?

IF THE conclusions of the National Safety Council's Committee on Spray Coating, as contained in its final report, are justified, it is safe in indoor work to spray materials containing appreciable quantities of lead (over 2 per cent), benzol (over 1 per cent), or of free silica, when the worker is protected by:

1 Adequate local ventilation producing an exhaust of 200 linear feet per minute. (Subsequent study may show that a lower velocity may suffice with improved operating conditions)

2 An efficient mask or respirator of the positive-pressure type.

The committee recommends that, wherever practicable, materials free from lead, benzol, and free silica be used in spray coating.

Spray coating unquestionably involves accident and health hazards, as is the case whenever an operator is brought into contact with harmful ingredients or impure atmosphere. This occurs even in brush painting, paint manufacturing, etc. In the past there has been no little controversy on the extent of these hazards, accompanied by both understatement and exaggeration.

Realizing that in such a controversial situation there was considerable danger to progress and appreciating the necessity of securing authoritative information upon which to formulate

NEW AMERICAN STANDARDS

The following standards were approved by the A.E.S.C. during the month of March 15–April 15, 1928:

Specifications for 30 Per Cent Rubber Insulation for Wire and Cable for General Purposes. (Tentative American Standard.)

Specification for Cotton-Covered Round Copper Magnetic Wire. (Tentative American Standard.)

Specification for Silk-Covered Round Copper Magnetic Wire. (Tentative American Standard.)

Specification for Enameled Round Copper Magnetic Wire. (Tentative American Standard.)

All four specifications sponsored by the American Electric Railway Association, American Institute of Electrical Engineers, American Railway Engineering Association, American Society for Testing Materials, Association of Railway Electrical Engineers, National Electric Light Association, Association of Edison Illuminating Companies, National Board of Fire Underwriters, and the National Fire Protection Association. Published by the A.S.T.M.

a guide to minimize any hazards to life and health which might be present, the National Safety Council, through its Chemical Section, proposed that an investigation of spray coating be made under the auspices of a committee composed of representatives of groups interested in the subject, and others who were qualified to give expert opinion.

The importance and value of spray coating was recognized, and it was hoped that if serious hazards were revealed means of obviating them that would not interfere unnecessarily with industry would suggest themselves.

The present investigation was initiated at the Cleveland Congress in 1925 when a steering committee was created to organize an intensive study of the problem. Comprising the steering committee were A. L. Watson, chairman, Lewis A. DeBlois, G. E. Sanford, S. E. Whiting, and Albert W. Whitney. Prof. C.-E. A. Winslow, of Yale University, was appointed chairman of the general committee, and Dr. Leonard Greenburg, United States Public Health Service, secretary. The actual conduct of the investigation was undertaken by Dr. H. F. Smyth and his associates who had recently completed a similar study for the Pennsylvania Department of Labor and Industry.

The three outstanding health hazards of spray coating arise obviously from the use of benzol, lead, and silica. The primary objective, therefore, was the detection of benzol poisoning, plumbism, and silicosis and their prevention. Such cases were to be sought principally among sprayers of lacquer, lead undercoats, and vitreous enamels. The first two ot these pointed directly to the field of automobile finishing, as this might be expected to yield satisfactory information on both benzol and lead; vitreous-enamel spraying should yield information on both lead and silica.

Copies of the printed report are obtainable from the headquarters of the National Safety Council, 108 East Ohio Street, Chicago, Ill. Price per copy, $1.00.

A.I.E.E. Submits Six Standards for Approval as American Standards by the A.E.S.C.

In CONFORMITY with a recent action of the A.I.E.E. Standards Committee the following six sections of the A.I.E.E. standards have been formally submitted to the American Engineering Standards Committee under Section 102 (*c*) of the new rules of procedure for approval as American Standards:

- No. 11 Railway Motors
- No. 16 Railway Control and Mine-Locomotive Control Apparatus
- No. 19 Oil Circuit Breakers
- No. 22 Disconnecting and Horn Gap Switches
- No. 33 Electrical Measuring Instruments
- No. 36 Storage Batteries.

The above list, together with those sections which have already been presented, completes the list of Institute Standards with the exception of three which are in course of revision (No. 1, General Principles upon Which Temperature Limits Are Based in the Rating of Electrical Machinery; No. 13, Transformers, Induction Regulators, and Reactors; No. 34, Telegraphy and Telephony), and No. 45, Recommended Practice for Electrical Installations on Shipboard. These will be presented later. In fact, power to present all A.I.E.E. Standards as they are completed to the A.E.S.C. for approval as American Standards has been delegated to the chairman and secretary of the A.I.E.E. Standards Committee.

Four of the Standards (Nos. 11, 16, 19, and 22) have been in effect almost three years; No. 33 over a year, and No. 36 since February of this year. This last Standard, on Storage Batteries, is a revision of the A.I.E.E. Standard on the subject, which had been in effect since 1922.

A.S.M.E. Boiler Code Committee Work

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in Mechanical Engineering.

Below are given records of the interpretations of the Committee in Cases Nos. 547 (reopened), 569, 578, 580–586, inclusive, as formulated at the meeting on February 24, 1928, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

Case No. 547 (Reopened)

Inquiry: *a* Is it permissible under the requirement of Par. P-186 of the Code to form corner joints between the shells and heads of power boilers by the use of fusion welding, where the shell is extended beyond the head and carries an angle or other structural shape riveted thereto on the inner side, so as to withstand the thrust on the head due to steam pressure?

b Is it permissible under the requirement of Par. P-186 of the Code to form the girth shell joints of firebox-type boilers having furnaces and water legs extending the full length of the shell, by fusion welding, when such joints are disposed half-way between adjacent rows of staybolting and the head-to-head stresses on the shell are fully carried by through rods and tubes?

c Is it permissible under the requirement of Par. P-186 of the Code, in firebox-type boilers, to weld the corner joints of furnaces that are subject to compressive stresses when both head and side sheets are supported by rows of staybolts close to the corners?

Reply: *a* If the shell is cylindrical or in the care of firebox construction is retained by staybolting, it is the opinion of the Committee that the use of such a structural member so disposed as to oppose the thrust due to steam pressure and properly attached to the extended shell by riveting according to the rules for circumferential joints, will not conflict with the requirement of Par. P-186. The angle or other structural shape should, however, be of such size that the bearing surface against the edge of the head is not less than 2 in. in width.

b It is the opinion of the Committee that while the through rods and tubes may perhaps be sufficient to withstand the calculated head-to-head stresses of such a firebox-type boiler, neither the longitudinal staying effect of the through rods nor the transverse reinforcement of the staybolting in the water legs will be sufficient to insure freedom of the girth joint from transverse tension stresses due to weight components or variations in temperature, and thus the construction proposed will not meet the Code requirement.

c It is the opinion of the Committee that while the staybolting will perhaps amply support the head and side sheets, their attach-

ment by fusion welding at the corners will not meet the requirements of the Code, as the welds would not be free from bending and tension stresses due to both steam pressure and contraction and expansion.

CASE NO. 569

Inquiry: Is it permissible under the rules of the Code, in the case of multi-longitudinal drum boilers, to place tees between the safety valves and the drums, and to connect the side outlets of these tees together?

Reply: It is the opinion of the Committee that Par. P-277 covers this arrangement completely and allows the use of such a connection as specified with certain restrictions.

CASE NO. 578

Inquiry: Is it permissible to insert a cross water grate header into the upper part of the firebox of a locomotive-type boiler as shown in Fig. 24, with attachment to the furnace crown sheet by means of fusion welding?

Reply: It is the opinion of the Committee that the construction is such that the load is carried by other parts than the welding, and that in accordance with the provisions of Par. P-186, there is nothing in the Code to prohibit the use of the construction as proposed.

CASE NO. 580

Inquiry: Is it the intent of the Code that where there is an extra allowance provided for the distance between the outermost staybolts of a flat stayed surface and the supporting flange or riveted joint at the outer edge of the sheet, as provided for in Par. P-205 of the Code, the outer row of staybolts shall support the entire area between them and the outside supporting edge, or is the extent of the supporting power of the outer row of staybolts limited?

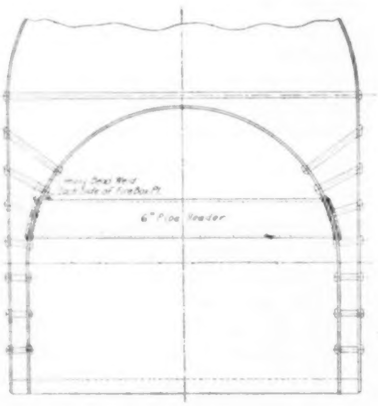


FIG. 24 METHOD OF INSERTING WATER GRATE HEADER IN FURNACE CROWN SHEET

Reply: Under Par. P-220*b*, where special allowance is made for the spacing between the outer row of staybolts and the outer edge of the surface to be stayed, the area to be used in computing the load on the staybolts is a rectangular area with the outer edge coming half-way between the limit line of the area to be stayed and the center line of the outer row of staybolts.

CASE NO. 581

Inquiry: Is it permissible, under the Code, to attach 4-in. circulating tubes of a furnace water wall to cast-steel elbows by fusion welding, the tubes being inserted into the elbows without threading and the welding being depended upon entirely for strength?

Reply: Autogenous welding of superheater tubes to headers or fittings is not permissible under Par. P-186 of the Code, where the strength of the welding is depended upon to resist the pressure tending to force the tube out of the header. Fusion welding is permitted in such construction only for tightness, where the stress due to steam pressure is fully carried by other construction.

CASE NO. 582

Inquiry: Is it permissible under the Code, where corrugated furnaces are required of greater length than can be made in a single piece, to join two corrugated-furnace sections by circumferential hammer welding at the middle, the hammer-welding process resulting in a flat portion about 6 in. wide?

Reply: It is the opinion of the Committee that such a method as described for joining two sections of corrugated circular furnaces is permissible under Par. P-243 of the Code, provided the plain portion at the circumferential weld does not exceed the limit of 9 in. and the maximum allowable working pressure is as specified therein for plain portions.

CASE NO. 583

Inquiry: Is it the intent of the Code for Low-Pressure Heating Boilers to require firebox steel plate to be used exclusively in any part of a low-pressure heating boiler?

Reply: It is not the intent of the Code for Low-Pressure Heating Boilers to require the use of firebox steel plate in any part of a heating boiler.

CASE NO. 584

Inquiry: Do the requirements of the Boiler Code regarding blow-off valves apply to economizers and water walls?

Reply: It is the opinion of the Committee that where water walls or economizers are integral with the boiler proper without intervening stop and check valves, they should be considered as part of the boiler, and all blow-off or drain valves which would empty the boiler should be installed in accordance with the requirements of Pars. P-308 to P-311, inclusive.

CASE NO. 585

Inquiry: Request is made for revision of the requirement in Par. U-20 of the Code which limits the maximum allowable unit working stress in seamless shells to 9000 lb. per sq. in. It is pointed out that for the drawing of seamless steel vessels, 55,000 lb. per sq. in. material is commonly and very successfully used, so that an allowable unit working stress of 11,000 lb. per sq. in. should be allowed.

Reply: This value of 9000 lb. for the maximum allowable unit working stress came from the table in the Power Boiler Code for piping and is conservative in view of the fact that the piping is provided for use up to a maximum temperature of 750 deg. fahr. It is the opinion of the Committee that for temperatures up to 600 deg., one-fifth of the ultimate strength can be safely used. This matter is under consideration for revision.

CASE NO. 586

Inquiry: Will it not be acceptable under Par. U-112*b* of the Code to use steel plate for forge-welding purposes with greater content of silicon than the specified limit of 0.05 per cent? Attention is called to the fact that difficulties with steel plate conforming exactly to the Specifications for Plate of Flange Quality for Forge Welding, extending over a number of years, have been overcome by increasing the silicon content of this material up to 0.15 per cent.

Reply: Par. U-112*b* is mandatory in its requirement that the quantity of silicon present in steel plate of this specification shall not exceed 0.05 per cent. This limit was fixed as a result of experience with steel for lap-welded pipe, but evidence before the Committee seems to indicate that the limit for silicon in steel for forge welding might safely be raised. It is therefore proposed to revise this feature of the requirement of Par. U-112*b*, and pending this revision it is recommended that this limitation on silicon content be waived.

The Conference Table

***T**HIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.*

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK, *Aeronautic Division*	*J. L. WALSH,* *National Defense Division*
A. L. KIMBALL, JR., *Applied Mechanics Division*	*L. H. MORRISON,* *Oil and Gas Power Division*
H. W. BROOKS, *Fuels Division*	*W. R. ECKERT,* *Petroleum Division*
R. L. DAUGHERTY, *Hydraulic Division*	*F. M. GIBSON and W. M. KEENAN,* *Power Division*
WM. W. MACON, *Iron and Steel Division*	*WINFIELD S. HUSON,* *Printing Industries Division*
JAMES A. HALL, *Machine-Shop Practice Division*	*MARION B. RICHARDSON,* *Railroad Division*
CHARLES W. BEESE, *Management Division*	*JAMES W. COX, JR.,* *Textile Division*
G. E. HAGEMANN, *Materials Handling Division*	*WM. BRAID WHITE,* *Wood Industries Division*

Applied Mechanics

Acceleration of Water Flow Through an Orifice

AM-3 If a vessel of considerable area filled with water has a very small orifice at a depth H below the surface of the water and this small orifice is opened in zero time, what time will be required for the velocity of the water issuing from the orifice to equal $\sqrt{2gH}$?

(*a*) An exact solution would be extremely difficult, if not impossible. However, an approximate answer would be that it is the time required for an elastic wave to travel from the orifice to the surface and back again. (Dr. P. S. Epstein, Professor of Theoretical Physics, California Institute of Technology.)

(*b*) The writer's answer would be that the time is the same as that required to accelerate a lamina of water having a thickness corresponding to the diameter of a molecule under the influence of the pressure head H and attaining the velocity of $\sqrt{2gH}$. The acceleration would be as nearly infinite as the mass above described is nearly zero. The writer does not know the weight per square foot of a film of water one molecule deep, and therefore cannot at the moment offer any better answer. (R. D. Johnson, Hydraulic Engineer, New York, N. Y.)

(*c*) As the writer views the matter, the answer would be indefinite. After the orifice is suddenly opened the velocity will rise along a curve and will approach the $\sqrt{2gH}$ value as an asymptote. The curve is of the exponential form. Theoretically therefore the velocity never entirely reaches the $\sqrt{2gH}$ value, but approaches it very closely in a limited time. The answer will therefore have to be in the form that within a certain time the velocity will reach to within a certain small but definite percentage of the steady value. (Lewis F. Moody, Consulting Engineer, I. P. Morris Corp., Philadelphia, Pa.)

Note: Since the above problem has a practical bearing on some hydraulic-turbine-governor problems, hydraulic engineers and other readers conversant with the subject are invited to continue the discussion in future issues. (Editor.)

Fuels

Air Jets as Aid to Smoke Abatement[1]

F-5 Is the introduction of air jets over the fuel bed of an underfeed stoker beneficial in the reduction of smoke and will the use of such jets prove detrimental to efficiency?

In general, air jets over the fuel bed of an underfeed stoker are beneficial in the reduction of smoke, but the use of such jets will reduce the combined efficiency of boiler and stoker. In general, the writer would not recommend the use of air jets over the fuel bed of an underfeed stoker, but special consideration must be given to the location of the stoker with reference to the boiler, the physical and chemical characteristics of the coal used, the effect of the distilled gases on the furnace linings, and the nature of the demand upon the boiler. (James W. Armour, Engineering Manager, Riley Stoker Corporation, Worcester, Mass.)

Comparison of Powdered-Fuel- and Hand-Fired-Boiler Operating Results

F-6 A certain power plant is equipped with four 350-hp. boilers in two settings of two boilers each. Hand-fired, using anthracite (buckwheat), the coal consumption was 1150 tons per month over a two-year period, with a rating of 70 per cent. It is said that the conversion of two boilers to pulverized-coal burners resulted in a coal consumption of 275 tons of slack for 420 steaming hours at 140 per cent of rating. The two boilers burning anthracite consumed 611 tons in 600 steaming hours during the same month. Readers are asked to criticize these figures, as they have aroused doubt as to their authenticity.

Concerning the above question which appeared in the April, 1928, issue, it is noted that the coal consumption of the pulverized-fuel burners was 275 tons per 420 hours, or 0.655 (2240-lb.) tons per hour.

The heat input (assuming 13,500 B.t.u. per lb. slack) = 0.655 × 2240 × 13500 = 19,804,000 B.t.u.

The output = 2 × 350 × 1.4 = 980 boiler hp. = 980 × 33 × 479 = 32,809,000 B.t.u.

$$\text{The overall efficiency then, } = \frac{32{,}809{,}000}{19{,}804{,}000} = 165.7 \text{ per cent,}$$

which is impossible.

There was evidently some error in the weight of fuel burned, or the steaming time may have been wrong. The above is not a question of rating, since 140 per cent can be easily maintained on small boilers. If the steaming time were reduced to 200 hours, the efficiency would be 78.9 per cent, which is possible on this type of unit. If the coal consumption should apply to one boiler, then the efficiency would be 82.8 per cent, which would still be very high for a small unit operated for the above period of time.

[1] This subject has been discussed in a previous issue.

The efficiency of the remaining two hand-fired boilers is 59.8 per cent (assuming 12,000 B.t.u. per lb.). This is a low efficiency with hand-fired small units. The initial operating statement of 1150 tons of anthracite per month for an output of 980 boiler hp. gives an efficiency of 76.3 per cent on an assumption of 12,000-B.t.u. fuel. This figure is too high for regular operation on hand-fired units. Furthermore, since two of the units give about 60 per cent, the remaining two that were converted to pulverized coal must have given an efficiency of about 92 per cent. The obvious conclusion, therefore, is that the measurement of the fuel was in error. (Emil F. Geile, Standard Oil Development Co., Elizabeth, N. J.)

Stoker Maintenance[2]

F-7 How much in cents per ton should average stoker maintenance run for (*a*) underfeeds and (*b*) chain grates? Please state what part of the figures given are for material and parts, and the portion allotted to labor of installation. Also state length of period over which the figures given have been averaged, and how recently they were compiled.

Stoker maintenance varies with the types of fuel, load, and operation. Average maintenance for both underfeed and chain-grate stokers should be from three to five cents per ton of coal for material and parts. Labor of installation also will be from three to five cents per ton of coal. These figures are based on general reports from various plants. No way is at hand for accurately checking these reports, however, and more reliance should be placed on average figures reported from individual plants covering a considerable period of time than on the figures given above. (James W. Armour, Engineering Manager, Riley Stoker Corporation, Worcester, Mass.)

Hydraulics

Air in Solution in Household Water System

H-1 A home water system consists of an elevated tank supplied by a hydraulic ram, with the usual house distribution system. Water is admitted to one end of the tank at the bottom and drawn off at the opposite end, also at the bottom, the two connections being about 12 ft. apart. The tank is air tight, and a pressure of 30 lb. per sq. in. is automatically maintained. A needle valve is supplied on the ram to admit air to reduce the level in the tank. Why is it that when this valve is opened wider than usual in an effort to lower the water level in the tank, a glass of water drawn from a faucet is filled with air bubbles, which pass off after awhile? There is no evidence that any of this air rises to the top of the water in the tank and the level is not brought down even by prolonged pumping with the needle valve wide open. Why does not the air rise to the top and reduce the height of the water level?

It is the writer's understanding that the amount of air which water will hold in solution is dependent upon the pressure. The higher the pressure, the greater the absorptive power of water for any gas. The writer's interpretation of the phenomenon would be that the air normally contained in the tank on top of the water does not dissolve readily in the water because of the lack of agitation of same, but that the air taken in by the needle valve in fine bubbles, passing up through the pipe and into the tank, has such a great contact surface and so agitates the water in the pipe that it becomes dissolved before it reaches the surface of the water—eventually charging the water with so much air in solution that it shows up in the drinking cup when drawn off and the pressure is released. (L. F. Harza, Consulting Engineer, Chicago, Illinois.)

[2] This subject has been discussed in a previous issue.

Miscellaneous

Ownership of Drawings

M-6 In general, are drawings made in engineers' offices the property of the engineering firm or the client? Give reasons.

(*a*) Custom over a long period of years seems to have established the engineering firm as the owner. Apparently there is no other reason for this condition. As the writer recalls it, only three times during his private practice of thirty-five years has the client requested the original tracings—in no case has he demanded them—and in these cases prints were kept for record in the office of the engineering firm. Probably there have been cases tried to establish ownership; however, the writer does not know of them. (Charles T. Main, President, Charles T. Main, Inc., Boston, Mass.)

(*b*) In the final analysis, this becomes a question of what the client desires when he employs an engineering firm to do work for him. In the first place, the client wants a structure and equipment to meet his needs. He employs an engineering firm to provide these for him, either because he does not have the time to build up his own organization to handle the job, or because it is cheaper for him to employ a firm with the proper personnel already organized than to build up his own organization.

Drawings of the structures and equipment are necessary for the client to properly operate, maintain, and repair the plant. Furthermore, the drawings are necessary for the investigation of any abnormal conditions that may arise, and for the extension of the plant by himself or by another engineering firm. The drawings he has of his plant should be suitable for making a number of prints at a nominal cost and therefore the client should have the tracings and not merely blueprints of them.

The client should have the drawings so that he may be sure that they are adequately protected from damage due to fire, etc. The client pays for the making of the drawings and therefore they should be his property the same as the structures and equipment constructed from them. In fact, a plant is not complete without a set of drawings and operation without them is at great inconvenience. (I. E. Moultrop, Chief Engineer, The Edison Electric Illuminating Company of Boston, Boston, Mass.)

Questions to Which Answers Are Solicited

Waste Hemp as Fuel

F-8 With what success has waste hemp been used as fuel under steam-generating boilers? Information as to methods of preparation will prove valuable.

Clinkering of Coal in Apartment-House Furnaces

F-9 Two apartment houses are equipped with identical furnaces. Anthracite coal of the buckwheat size is fired in each. In one furnace the coal burns to ash; in the other it clinkers badly. What do readers consider possible causes of this condition?

Furnace Gas in Pneumatic Conveyors

MH-4 It is proposed to use furnace gas as a conveying medium in a pneumatic conveyor, thereby performing both conveying and drying operations simultaneously. Does such an arrangement seem feasible in the face of existing data?

Critical Speeds of Cast-Iron Gears

MS-1 What are the critical speeds of cast-iron gears in feet per minute?

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

The American Society of Mechanical Engineers

29 West 39th Street, New York

American Research in Cutting Metals

THERE is included elsewhere in this issue a review of a recent German book on metal cutting. One of the significant features pointed out by the reviewer is that only two or three American publications are quoted in this text, which is primarily a critical analysis of available research data on the turning of metals.

There is food for thought in this situation which cannot be explained with entire satisfaction by the author's lack of familiarity with American technical literature, since the subject has been treated with thoroughness and a reasonably complete knowledge of the subject from both theoretical and practical points of view. Rather it would seem that there have been few outstanding American contributions to command attention since the work of Taylor and his associates. This is far from a satisfactory situation in the country which contributed so largely to the outstanding early developments in the art of cutting metals.

One can only guess at the causes, but there are ways to remedy such undesirable conditions.

Researches in metal cutting are comparatively costly, since extensive work is usually required on the part of operatives who combine a high order of technical ability with a broad background of practical experience. Few organizations can, single handed, afford to finance fundamental work in this field since the direct returns from large expenditures are frequently small. Well-directed research will ordinarily result in measurable progress, but commercial advantages are often evident only after progress becomes cumulative.

One obvious solution to this problem is by group attack, on the part of the producing and consuming interests most directly affected. Under such conditions the division of the expense will improve the chance that the direct benefits will be commensurate with the cost to individual organizations.

Cooperative research of this sort has been used successfully in other fields both in this country and abroad. It is even now being applied to the field of metal cutting in England and elsewhere. In its Research Committee on the Cutting of Metals The American Society of Mechanical Engineers already has the nucleus of a useful organization for similar work in this country, but so far the industrial support of organized work in this field has not been on a par with that in other lines.

There can be no question that there are problems to be solved, and there should be no great difficulties in perfecting an organization capable of their solution. More active support and interest in this field which advances our fundamental knowledge of the laws of metal cutting cannot fail to bring direct benefits to industry. Can we afford to neglect the opportunities offered by organized, well-directed research in this field?

The Steel Industry

IN THE past the steel industry was considered to be highly stable technically. Changes did take place and, for example, during the five years preceding the war the bessemer process gradually lost its supremacy as a maker of steel to the open-hearth. This was, however, a very gradual change, to which the industry as a whole had ample time to adjust itself. What might be called "overnight" changes were practically unknown. This was ascribed to the fact that the founders of the industry who laid the basis of the fundamental principles of the making and shaping of steel had built so soundly that only the wear of time, and that but slowly, could displace what they had done.

The result was a kind of complacent attitude among steel makers, both engineers and executives of the big companies (the discussion here deals with tonnage goods and not specialties or high-cost alloys). In a world where everything was changing, steel alone stood unaltered and apparently unalterable—a kind of industrial Rock of Gibraltar. This attitude has been quite rudely shaken within the last couple of years. First came the continuous rolling of sheet. The continuous rolling of billets and wire rod was of course an old story, but in the past a mention of rolling continuously wide sheet in an engineering meeting was sure to provoke smiles of derision. This was "a thing that simply could not be done," but it was done, and done so successfully that enough mills are now under construction and in operation to replace by continuously rolled material the product of the major part of the existing hot-rolled pack sheet mills. In fact, some enthusiasts claim that hot-rolled non-continuous sheet will take its place as a museum exhibit within the next few years. If it does, it will not lack company, for it will probably be joined on the museum shelves by another product of the steel mills, namely, welded pipe. Up to two or three years ago seamless tube was available in small sizes only, and then at a cost which did not permit its use outside of a fairly restricted number of applications. For sizes above 6 in. only welded pipe was available, and this constituted the major item of production of a number of steel companies.

Among other things, welded pipe has been used in oil drilling and given fair satisfaction until within the last few years when deep drilling was resorted to. This brought about an insistent demand for seamless casing pipe, and this demand has been satisfied so well that there is every indication today that seamless tubing in sizes from 6 up to 14 or possibly 16 in. either can already or will soon be made at a cost which will permit it to compete with welded pipe.

The American Society of Mechanical Engineers will have at

its Spring Meeting a paper by R. C. Stiefel and Geo. Pugh, describing some of the recent developments in this line, and telling among other things how large-diameter tubing can be made from comparatively small-diameter billets, which fact will be probably instrumental in reducing still further the cost of manufacture of seamless tubing.

The only argument in favor of welded pipe in the past as compared with seamless tubing has been its lower cost. Otherwise it appears inferior to seamless tubing in every way, and if the latter can really be made and sold for the price of welded pipe there is no reason, at least in standard sizes, why it should be longer made.

The Youngstown Sheet and Tube Co., the Jones & Laughlin Steel Corporation, The Pittsburgh Steel Co., and the National Tube Co. are already making large-size seamless tubing, and several other companies are preparing to get into this field. The recent merger of Spang-Chalfant Co., an old-established manufacturer of welded pipe, with the Standard Seamless Tube Co. would indicate a tendency in the same direction.

The foregoing is not the only change pending in the steel industry. The National Tube Company at Lorain is actively working on a method of producing steel (or rather of a material for charging into open-hearth furnaces) direct from ore. Those who have invested money in blast furnaces have no occasion to worry as yet, but no one knows just when they may. Benj. Talbot at the Merchant Iron Works in Middlesbrough-on-Tees, England, is operating an open-hearth furnace with a reheating attachment which is claimed to increase the output more than 25 per cent, a fact which may not be very welcome to the industry, fully equipped as it is today. Several other developments which have not yet reached an equally definite stage might also be mentioned, all of which show that in the steel industry the tendency toward change, improvement, and saving in costs and labor is actively at work.

Cooperative Research in Oil-Engine Power

AN EDITORIAL entitled "Overlapping in Research Work," in the February, 1928, issue of the British journal *Motor Ship*, is suggestive of a sensible procedure adopted by British engineers interested in the design of Diesel engines. It appears that one of the objects of the formation of the British Marine Oil Engine Manufacturers' Association was the pooling of results of research work. Attention is called to the fact that little has been published although the work is frequently discussed, and the suggestion is made that further activities be undertaken to prevent the overlapping of effort and the dissipation of funds, time, and energy over problems that have been found to be unfruitful, and over others which are so fundamental as to fit into a program of cooperative research.

The American Society of Mechanical Engineers, through its main Research Committee and the Oil and Gas Power Division, is the agency in this country through which cooperation in research in this field should function. Problems which have a general bearing on the industry as a whole can best be solved by cooperative effort. The combined resources of the entire industry are available, the best personnel and laboratory facilities can be selected, the cost can be properly distributed, and the results shared by every one interested, including the engineering profession as a whole.

The Oil and Gas Power Division has already made a start in this direction. The Survey Committee of this Division has canvassed its members and has prepared an extensive list of research projects which it is submitting to the main Research Committee of the Society as needing solution.

As the British editorial takes pains to point out, cooperative research is not intended to supplant the individual investigations which all manufacturers will find necessary for the solution of their individual problems or for the development of improved designs. The manufacturer merely pools his interests with those of his competitors in the investigation of problems affecting the industry as a whole. Manufacturers of Diesel engines, and designers and engineers in general, should give their hearty support to the efforts of the Oil and Gas Power Division to carry through a coordinated program of research work.

Unemployment in the United States

CONSIDERABLE attention has been given lately to a statement by the Secretary of Labor to the effect that there are at present about 1,700,000 unemployed in this country and that this situation deserves serious attention. As there has at the same time been a good deal of talk about machines displacing men, there is a tendency to link the mechanization of industries with the unemployment situation.

The best source from which to draw any conclusions as to the causes and character of present unemployment is, however, lacking, namely, a knowledge of the facts, and more specifically, of the industries in which unemployment exists, the length of time it has existed, and the reasons why the men released by these industries cannot find other work.

As compared with periods of unemployment in the past, the present one is very unusual. Within the last fifteen years there have been three periods in this country when unemployment was a serious matter. One followed the passage of the tariff bill at the beginning of the Wilson administration; the second was directly traceable to the World War and lasted from September, 1914, to the latter part of 1915; while the third and most serious one occurred in 1921 as a result of the deflation of wartime values. In all of these cases unemployment was coincident with a marked decline of industrial production and a similar decline of investment values.

At present such unemployment as there is appears to be concurrent with an enormous volume of production—very close to the peak for all kinds—and such a violent upturn in the value of industrial stocks as the country has never before seen. It is all true, of course, that in such times as the present the Stock Exchange is not an accurate barometer of the state of business in the country, but operations on such a scale as those within the last three months, even if tinged with the spirit of gambling, could not be carried out without an enormous amount of capital being contributed by the public; and the ability of the public to invest or use for speculation such enormous sums does not indicate a state of depression of the business of the country. We have, therefore, the unusual juxtaposition of a buoyant spirit in business and unemployment, which a cabinet officer says deserves serious attention.

When we review the industries we find that there is a serious strike in one of the soft-coal regions. The hard-coal industry is not doing as well as formerly, because of the loss of certain of its markets to oil, soft coal, and coke. The textile industries are going through one of their periodical labor troubles, and a cut in wages of 10 per cent has just been announced in the New England mills. The other major industries, however, are working at very nearly top speed, and there is no indication of a slowdown or cut in wages either present or prospective.

The building industry, it must be confessed, is at best spotty. During the period from 1921 to about 1926 this industry had not only to satisfy current requirements but the demand accumulated during war years when excessive cost of labor and materials, and later direct Government regulation, interfered with construction. The result was that a tremendous boom was created.

Wages went up and employment was plentiful. This naturally attracted to the building industry a considerable amount of labor. Since 1926, however, it has been gradually slowing down, except in some of the larger cities like New York, and even in these cities, although the volume of building is still very large, a return to normalcy is in sight. It is known that there is throughout the country considerable unemployment in the building trades, although its volume has never been reliably determined.

Another big industry which apparently has been releasing men is agriculture, where the introduction of tractors and power-operated machinery has undoubtedly reduced the number of "hired men" as well as their status. This tendency has been rapidly growing and is apparently responsible now for a certain amount of unemployment.

There is another element which must be given more consideration than it usually receives, and that is the appearance of a new class of labor, namely, female labor. Women were, of course, employed in the industries to a considerable extent in the past, but this employment was more or less of a distress character.

The introduction of mechanical devices, in particular handling and manipulating machinery, has largely converted the modern workman from a man who does things with his muscles to one who supervises the operation of machinery and makes it perform the heavy tasks by merely pushing a button, pulling a lever, or directing a handle. Further, it has made it possible for women to undertake work in factories where previously men had to be employed because the character of the work required the possession of physical strength and endurance.

No clear conclusion as to the character of the present unemployment can be drawn until data become available regarding the extent to which women have taken men's places in the industries.

When we take all of these factors into consideration it will appear fairly clearly that if out of a population of 120,000,000, which means about 45,000,000 male persons old enough to be capable of earning a living, only 1,700,000 are unemployed (less than 2 per cent), the number of men displaced directly by what has come to be known as the mechanization of the industries must be very small indeed.

What Is the Professional Status of the Engineer?

On numerous occasions the professional status of the engineer has been compared with that of the lawyer, the doctor, and other professional men. Quite often he has suffered by such comparisons, largely due to the scarcity of authentic information. Experience has proved that as long as erroneous information is allowed to circulate, fancied conditions may be expected to increase in severity to a point where they seem almost intolerable. Many engineers have long felt that a comprehensive investigation of their field is imperative if unrest and dissatisfaction are to be eliminated.

This subject was discussed at considerable length at the Council Meetings of December 9, 1927, and March 15, 1928. On the latter occasion, Thos. H. Normile addressed them on "The Economic Status of the Mechanical Engineer—Can It Be Improved?" The information contained in his paper, which appeared in the April 22, 1928, issue of the *A.S.M.E. News*, disclosed many conditions of vital interest, and suggested several possible approaches to the problem that should prove of value to any agency charged with its further treatment. Representatives of the Professional Divisions in their conference on the same day learned of the work of the Railroad Division along these lines in the railroad and railroad-supply industries. A brief description of the activities of the Division's Committee on Professional Service appears on page 332 of the April, 1928, issue of Mechanical Engineering.

The possibilities of a general investigation of the mechanical engineering profession so appealed to the Council that the President was requested to appoint a Committee on Professional Service to promote and supervise an investigation of the opportunities offered in the several fields of mechanical engineering. Each of the Professional Divisions and the Local Sections has been invited to suggest the names of men of affairs interested in this subject for consideration by the President of the Society in selecting members of the above-mentioned committee to advise how the Society can best promote the welfare of the profession.

One thing seems certain at this time, however, and that is the importance of emphasizing the value of the engineer to the community. Those who lament their fates are entitled to know the facts. If the engineer is not appreciated for his actual worth we should know about it, and steps should be taken to elevate him to his rightful plane. If he actually stands high in the opinions of those who are not engineers, then it is well to know that also. Perhaps it will act as a tonic to those who are inclined to despair of their outlook to know that recognition is theirs. No matter what the proposed investigation may bring to light, it will at least make available facts; and false rumors and gossip, the bases of most unrest, find incontrovertible evidence decidedly unhealthful food.

Cleveland's Survey of Her Industrial Water Supply

Every geographic and economic consideration would appear to favor the industrial development of Cleveland as a center for all kinds of heavy industries—steel, oil, etc. For a while this development proceeded very rapidly. Then came a slowdown. The Cleveland Real Estate Board undertook the survey of one of the features on which the future industrial development of the region depends, namely, the water supply for its industries, flood control for the Cuyahoga River Valley, and the possibility of extending the limit of navigation upon and the straightening of that river. This is the first attempt that has ever been made to study the industrial-water-supply problem in all its larger aspects, and is of interest both because of the importance of the problem undertaken and the thoroughness with which the work has been done.

The geographic position of Cleveland is particularly favorable for the economic production of iron and steel, and it is stated that the three principal ingredients used in the manufacture of pig iron are assembled there nearly $2 cheaper per ton of pig iron than at Pittsburgh or Youngstown, and $1.50 per ton cheaper than at Chicago. It would appear, however, that the navigation facilities in so far as the steel industry is concerned are already inadequate, and the site of the Otis Steel Company is the last place that can be reached in that way. Land further up stream is available, but if it is opened up for industrial purposes the water-supply situation will become aggravated.

The study of the economic relation between plant efficiency and water temperature would indicate that existing industry will save approximately $^1/_4$ cent per 1000 gal. of water if a supply from the lake or impounded river water is substituted for the existing river supply. This figure does not include such benefits as decreased operating costs, reduced shutdowns, etc.

It costs industry one to two cents per thousand gallons to pump water from the river into its plants. If the new supply can be made available to industry at a cost of one-fourth cent without head and one and one-fourth cents with head, the water will cost approximately what it now does in plants pro-

vided with efficient pumping machinery. Further, the plants will realize on the value of cleaner water, and if it can be supplied more cheaply, industry will profit in the way of a definite financial saving.

In the analysis of the value of a cooler water supply, the calculations have been limited to the existing uses of water. The value to an increased consumption from future industry is necessarily precluded. New industries of any magnitude cannot locate in the valley unless additional supply is furnished. The intrinsic value of water to a new industry is therefore more than that to an industry which already has a supply and is concerned only in increased plant economy.

Several sources of water for industrial purposes are next discussed in the survey, Lake Erie coming first. In as much as this would be a cool, clean water under pressure, industry would substantially benefit from such a supply. It would virtually be necessary, however, for all existing industries to agree to use the water. As stated previously, the supplying of water from another source will benefit the quality of the water in the river during the summer. But if only some of the users were to obtain water from another source than the river, others would profit by the improved condition of the river and the quantity sold would not be so large and the price would thereby be increased beyond a reasonable figure to the user.

The survey has also covered comprehensively the subject of impounded supply from the Cuyahoga River. Here the subject of fluid control is of importance and the construction of two kinds of dams, 60-ft. and 95-ft., is discussed.

From this report it would appear that substantially such a program as the creation of an industrial water supply for a district like Cleveland could be carried through with modern means of construction at a comparatively moderate initial investment, but to be effected would require the thorough and hearty cooperation of many interests, such as the state, the township, and the municipal bodies involved, very probably the federal government, and above all, practically unanimous support and cooperation of the existing large industries. The report is valuable as an analysis of existing and possible supplies, and points the way to what should be done in other districts where the question of water supply for industrial purposes is more urgent, as, for example, in the Shenango Valley in Pennsylvania.

A Dictionary of Biography

ANNOUNCEMENT has been made of the publication of the first of the series of twenty-two volumes to be known as the "Dictionary of American Biography," edited by Prof. Allen Johnson for the Council of Learned Societies, Washington, D. C., through the enterprise of the New York *Times*.

This great undertaking has for its object the presentation of authoritative biographies of men and women whose lives have touched their times and environs in such a way as to stamp them as being made of more than ordinary clay. There will be brought to the attention of the student of our social and economic history not only the Washingtons and the Lincolns, the Whitneys, the Emersons, and the Poes, but those also of lesser fame, not exactly "mute inglorious Miltons," but erstwhile "favorite sons" whose words at one time were tribal law and whose names, perhaps otherwise forgot, were once heard on the Rialtos of young but rapidly growing cities.

The history of peaceful progress is seldom spectacular, and those who foster it are not material for epics. Yet here are some about whom we wish to know more. There is, one remembers, that priest-king Melchisedec, of whom remains, beside his name, only the suggestion of a sublime influence; and there is that nameless peasant-husband of Electra's, immortalized in drama by Euripides, whose sterling qualities can still inspire.

The sturdy citizens of past generations are soon forgot in the interest which the present has in the monuments to their industry and creative genius. One finds in these biographies, reproduced as accurately as is possible from the sometimes extremely meager data available to the biographer, the personalities of yesterday, men whose records are now, for the first time, in many cases, easily located. Particularly in the case of engineers and industrialists, whose biographies are of greatest interest to our readers, has the material been hard to obtain because personalities have been less spectacular than achievements, and the individual has become merged with the industry or profession.

A list of the names included in Volume 1 of the Dictionary, printed in the New York *Times* for February 26, 1928, carries with it a request that notable omissions be called to the attention of the editor. Engineers can perform a valuable service by thus assisting in the accumulating and authentication of data on the lives of those about whom they may have important and unpublished information.

Increased College Tuition

IN COMMON with many other costs, college tuition fees have increased markedly since the war. The advances with which all businesses and industries had to contend did not escape the colleges, with a resulting burden upon alumni, benefactors, philanthropists, and endowments, and an ever-increasing problem for administrative officers. To most colleges it has seemed no more than proper that the individual student should pay a greater proportion of the educational expense, and tuition fees have been raised accordingly.

An investigation of the increases in fees in privately endowed colleges, with a comparison of them with the general trend of economic conditions, has been made by the John Price Jones Corporation of New York, and the results have been published.[1] Twenty-one men's and nine women's colleges were studied for the period from 1907 to date. In men's colleges, fees increased from an average of $125 in 1907–08 to $329 in 1927–28, an increase of 155 per cent; for the same years in women's colleges the average tuition fee rose from $147 to $343, an increase of 133 per cent.

To enable an intelligent analysis to be made of the significance of this rising cost of education, the results are compared on a basis of index numbers with those of other economic conditions. For the year 1925–26, the last for which complete figures are available, the following comparison is given in the report, the index numbers for 1913–14 being in each case taken as 100:

	Index figure (1913 = 100)
Tuition fees	198
Income per capita	228.5
Cost of living	203.5
Retail food prices	157.4
Deposits—National and savings banks	271.3

Interpreting these figures broadly, it would appear that there is no greater hardship incurred by the student of this generation than there was by his predecessor in 1913 in so far as tuition charges are concerned; and indeed, the great increase in college attendance since the war seems to bear out this idea. Yet there are today, as there have been always, hundreds of young men of worth and promise whose circumstances do not permit them to indulge in the benefits of a college education. This, rather than the rising cost of tuition fees, is the problem of greatest concern to educators and society in general.

[1] "Tuition Fees and College Financing," the John Price Jones Corporation, 150 Nassau St., New York, N. Y.

A.S.M.E. Special Research Committee on Condenser Tubes

Contemplated Work of the Sub-Committee on Questionnaire

THE SUB-COMMITTEE on Questionnaire of the A.S.M.E. Special Research Committee on Condenser Tubes having mapped the localities according to degree of condenser-tube deterioration (MECHANICAL ENGINEERING, Feb., 1928), is contemplating further work in an endeavor to find what effect various circulating-pump and condenser designs have upon the turbulence of the circulating water within the water boxes and tubes in so far as this effects deterioration.

It has been suggested and substantiated by tests that turbulence and the accompanying entrained air within the water box and tubes have a marked effect upon the deterioration of condenser tubes. Accordingly the Sub-Committee will in the near future circularize a number of the larger companies with a questionnaire designed to provide the necessary data.

The accompanying illustrations, Figs. 1, 2, 3, and 4, indicate the method employed by one of the larger public-utility companies to note the degree of turbulence within the water box. Figs. 1 and 2 show the essentials of the apparatus, namely, an electric bulb within the water box and a glass observation plate installed in the water-box door.

Fig. 3 shows the water within the condenser immediately after the circulating pumps were started. Comparatively large

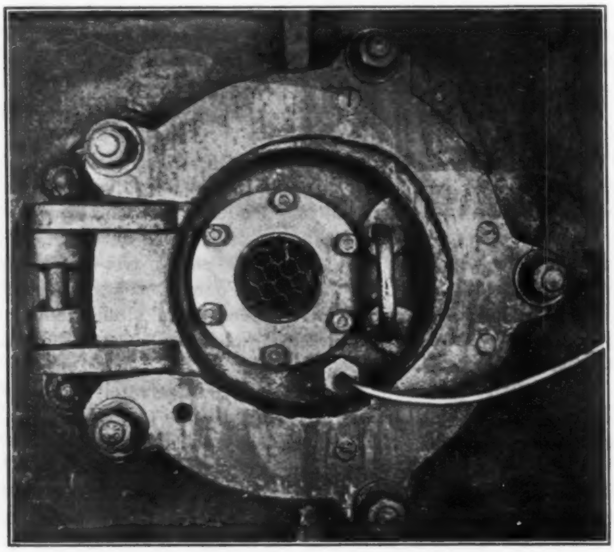


FIG. 1

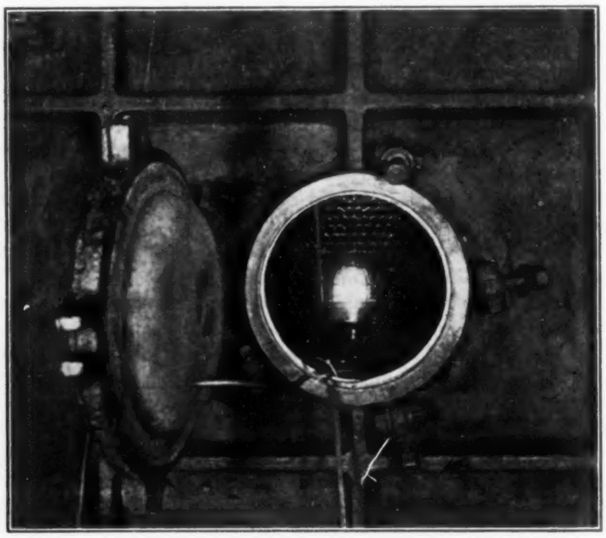


FIG. 2

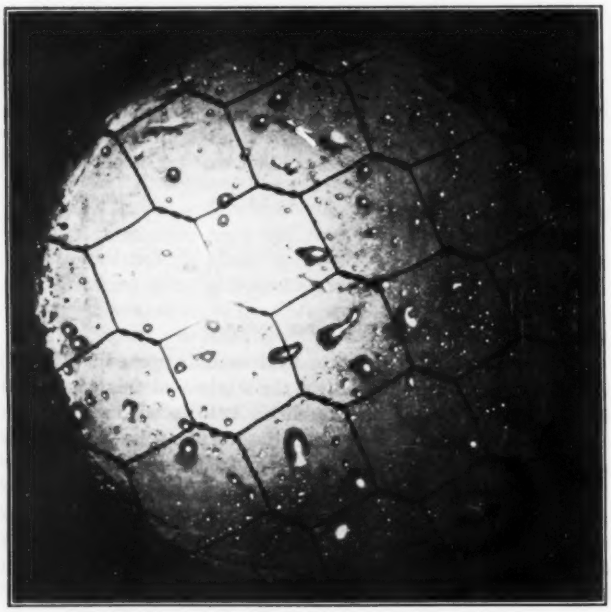


FIG. 3

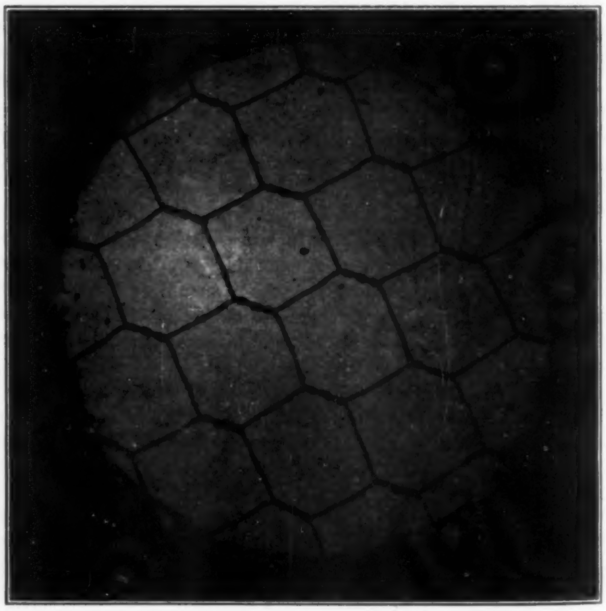


FIG. 4

bubbles of air may be seen close to the inside of the glass observation door. It was also observed that the water within the water box assumed a milky tint, indicating the presence of air in the form of fine bubbles. The photograph, Fig. 4, was taken after the pump speed had increased, and as compared with Fig. 3 indicates quite plainly the milky appearance of the water.

The Sub-Committee proposes to interest other companies in making similar observations and in this manner add to the present knowledge regarding turbulence and entrained air within condensers.

The Gray-Iron Conference in Pittsburgh

A CONFERENCE of gray-iron foundrymen was called at the Carnegie Institute, Pittsburgh, on March 13 to consider the conditions existing in the jobbing part of the gray-iron industry and to discuss possible remedies. Judging from the various addresses made, practically all by gray-iron foundrymen themselves, the jobbing business in gray iron is falling upon evil days. In the first place, it is meeting a powerful competition from other industries. Pressed steel, die castings, machine parts. and to a certain extent even steel castings are used where in the opinion of the gray-iron foundrymen gray iron could be used to equal or better advantage. Moreover gray iron, it appears, is not viewed very highly by either engineers or the public, the general impression being that it is a weak or unreliable material, and can be used only where the stresses are either low or may be neglected entirely.

Many users of gray-iron products when they reach the stage where their requirements become really substantial, put up foundries of their own and then in order to keep the foundries running, particularly in slack times, go into the jobbing business, thus creating a competition with concerns that rely on that kind of business for their living. The new method of hand-to-mouth buying has also cut into the business of gray-iron foundries by splitting up the orders and thus inducing a more acute competition.

The speakers outlined substantially three ways of attacking the problem. Some of them claimed that the reason why they are not getting as much business as they deserve is that engineers and the general public have been allowed to form a low opinion of the properties of gray iron. Gray iron has been attacked vigorously from several angles, and no one has risen in its defense. The speakers pointed out among other things how parts for vacuum cleaners and washing machines which were first made in cast iron were switched to welded or pressed steel, only to come back to the original material when it was found that the new substitutes were less satisfactory.

In this connection an interesting parallel was drawn in regard to what had happened to the rivet trade. Representatives of the welding industry had publicly made the claim that welding was superior to riveting. Had the riveting industry, according to the speakers at the Gray-Iron Conference, allowed this claim to go unchallenged it would have undoubtedly been severely injured. Actually, however (all of this is reported here from addresses at the conference), the rivet manufacturers made counter addresses at the meetings of important societies, such as The American Society of Mechanical Engineers, and brought out the good points of riveting with such telling effect that attacks on it have been greatly moderated. A virtue even has been made of the noise of the riveting hammer as indicating the rising prosperity of the community where it is heard.

The next line of attack suggested was in the direction of a better technical study of gray iron. It was pointed out that by these means and by better control of production the position of the malleable-cast-iron industry had been greatly improved. The work of the Research Committee of the American Foundrymen's Association and of the Bureau of Standards was referred to, and it was stated that the measurement of temperature of molten metal had been successfully carried out and that search is now being made to find a test for the fluidity of molten metal, none being as yet available.

The third line of defense suggested was an organization of the industry with various more or less ambitious purposes. In this connection one of the gentleman present read a report telling what vast amounts of money are being spent by the various trade organizations in the interests of their products, these amounts running in some instances as high as several millions of dollars. An item which appeared to have particularly impressed the audience, as several speakers referred to it subsequently, proved to be an expenditure of $50,000 a year by a national association of manufacturers to make America "sauerkraut minded."

It was suggested, therefore, and later unanimously carried by a vote, that an American Cast-Iron Institute be formed with such purposes as might be ultimately decided upon by a committee to be appointed by the chairman. The purposes of this Institute would be, first, to foster research on cast iron with a view to improvement of this material. Next would come a search for new fields where cast iron could be used. Publicity along such lines as carried out by the American Brass Manufacturers' Research Association, lamp manufacturers' associations, etc., was the next aim indicated, and some of the speakers added even the possibility of eliminating foundries which have no economic justification for their existence, although no details as to how this could be done without running athwart the Sherman and Clayton laws were indicated.

An interesting feature of the conference was that both the chair and some of the speakers emphasized that the problem was entirely one for the gray-iron manufacturers themselves, and that no outsiders were wanted in the movement. In fact, the rules of the conference provided that only gray-iron makers and specially invited guests, of which apparently there were none, could take part in the discussion. This is interesting, because as the problem facing the gray-iron makers is that of selling more castings, it would appear that the opinion of the buyers of castings ought particularly to be sought. In this case the sellers were deciding what should be done for the industry, outsiders, which of course includes the buyers, being kept out of the discussion.

The conference was of interest also in showing how industries are beginning to react to the phenomenon called, for the sake of brevity, competition between industries. The expression attributed to Benjamin Franklin that "we shall all have to hang together or hang separately" is apparently being taken to heart by the industries that want to survive. Some industries have not needed it as yet—for example, in the coal industry the various districts are murderously competing with each other, with well-known tragic results to all of them. Other industries, however, are gradually getting together, forgetting such internal grudges as there may have been and endeavoring to present a united front to those who would invade what they consider their legitimate territory. Even if the proposed American Cast-Iron Institute does not succeed in making American engineering more "cast-iron minded," it will certainly contribute toward the improvement of a product which has a well-deserved and important place among the major materials of modern engineering.

William Freeman Myrick Goss Dies

Thirty-Second President of the A.S.M.E. Passes Away in New York at Age of Sixty-Eight

WILLIAM FREEMAN MYRICK GOSS, retired educator and President of The American Society of Mechanical Engineers in 1913, passed away on March 23, 1928, in New York City at the age of sixty-eight. He joined the Society in 1886, eventually becoming a life member, and served it as Manager from 1900 to 1903, and as Vice-President from 1909 to 1911.

Dr. Goss was born in Barnstable, Mass., October 7, 1859. In the fall of 1877 he entered the then recently established mechanics arts course at the Massachusetts Institute of Technology. Upon completion of the two-year course he was appointed instructor in practical mechanics at Purdue University, and at once began there the work of establishing shop laboratories. His first class of five students was given instruction in those lines of work in which he himself had just been trained. From a meager beginning, the outlook broadened rapidly. The equipment was extended, the number of students increased, and new shop laboratories were built. In 1883 he became professor of practical mechanics, a title which he held for seven years. When he began, there was no college west of the Alleghany Mountains giving systematic courses in shop practice, and there was no manual-training work in any American high school. He devised courses of practice and developed series of lectures by means of which principles established in the shops could be given wider application. It was a day when school officials were becoming interested in training students in the manual arts, and many distinguished visitors went to see the work of the Purdue laboratories. The great cities of Chicago, Toledo, Louisville, and Indianapolis each in turn sought its aid in the establishment of their manual-training schools. Certain forms of equipment, especially forges and lathes, originally designed and constructed at Purdue, were made and supplied as complete equipment to school boards in distant localities where new courses of shop practice were being organized. In many such ways the work at Purdue had an important part in ushering in an educational movement of unusual significance.

William Freeman Myrick Goss

In 1889, after ten years of this work, Dr. Goss was given a leave of absence, and took up his residence in Boston, where he continued from April of that year to a year from the following September. Some work was done at the Massachusetts Institute of Technology, but the greater part of the time was given to self-directed reading and study. In the spring of 1890 he was appointed professor of experimental engineering, and he undertook the active duties of his new office in the fall of that year. Having developed laboratories for elementary training, it was now his task to build laboratories for advanced engineering work. A modest steam-engineering laboratory equipped with a compound Corliss engine and a few testing machines was soon in operation. Plans for an extensive engineering building (Purdue's present engineering laboratory) were developed, and by the fall of 1891 a portion of the building was constructed. A significant part of the equipment of the new laboratory was a locomotive testing plant designed to serve in an experimental study of locomotive problems in much the same way that an experimental stationary plant could be used in studying the problems of design affecting the performance of stationary engines. This locomotive testing plant was the first of its kind. It was designed in the summer of 1891 while the building which was to contain it was in the process of erection, and was in successful operation in the late fall of the same year. An incident in the process of installing this plant was that of transporting a 100,000-lb. locomotive over the cornfields and highways which intervened between the nearest track and the laboratory, a distance by the course taken of about a mile and a half. The opportunities which were presented to its possessors at once attracted the attention of motive-power men and of steam engineers. So meager was the information concerning the performance of locomotives that every fragment of truth, however simple or easily obtained, at once became a matter of public interest. The evaporative capacity of the locomotive boiler, its efficiency at different rates of power, the power and efficiency of the cylinders, and the effect upon power and efficiency of changes in speed or cut-off were all matters which previous to the introduction of this plant had been but little understood even by those best informed. The behavior of the various parts of the machine as a mechanism and especially the effects produced by the action of the counterbalance in the locomotive drive wheels were all matters concerning which people had theories, but which were first actually developed by the accurate processes of the laboratory at the Purdue plant. Associations of railroad men gave their encouragement and sometimes financial assistance in increasing the output of the plant. The Master Car Builders' Association made the Purdue laboratory its official testing station, and was instrumental in installing there a considerable amount of useful and expensive apparatus. The laboratory became an active center for testing not only locomotives, locomotive fuels, and

locomotive lubricants, but also details of car construction such as wheels, axles, draft gears, couplers, and brake shoes. The problems awaiting solution were always numerous, and the professor in charge was kept busy outlining the means to be employed in solving them. He was in the beginning responsible not only for the effective use of the railroad equipment to which reference has already been made, but also for the development of laboratories and courses in materials testing, in hydraulics, and in the general field of theoretical and applied thermodynamics. He erected buildings, purchased and installed equipment, and in many cases the equipment installed was of his design, and he was required to meet the reasonable expectations of an ever-increasing body of students. Hundreds of men, students at Purdue in the early nineties, can testify to the variety of the activities which in their day were in progress in the engineering laboratories.

In 1899 Dr. Goss was again granted a year's leave of absence which he spent in travel and study abroad, chiefly in Germany. Upon his return he was appointed Dean of the School of Engineering, an office which he continued to hold throughout the remaining eight years of his residence at Purdue. In 1907 he resigned his position at Purdue, after twenty-eight years of service, to take up what seemed to him the larger and more responsible duties of Dean of the College of Engineering of the University of Illinois.

In 1913 Dr. Goss was granted leave of absence from his duties at the University of Illinois to become Chief Engineer of the Chicago Association of Commerce's Committee on Smoke Abatement and Electrification of Railway Terminals, succeeding Mr. Horace G. Burt. This work involved a detailed study of the extent to which smoke from railway operations constituted a public nuisance and menace to health in the city of Chicago and a detailed study of the cost, technical feasibility, and financial practicability of the complete electrification of the railway terminals of Chicago. A complete report covering these studies was compiled under the direction of Dr. Goss and issued in printed form in December, 1915.

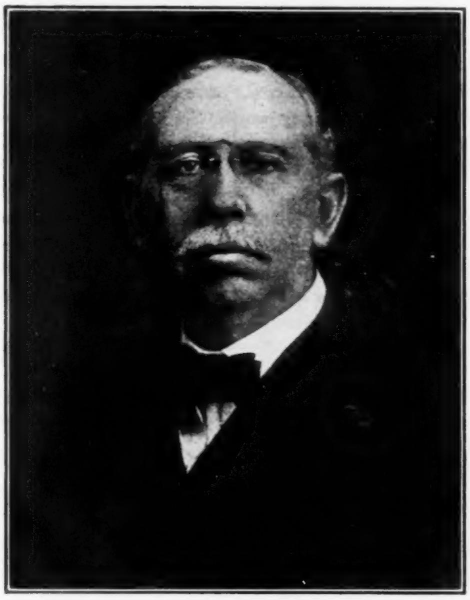
At the conclusion of this work, Dr. Goss resumed his duties as Dean of the College of Engineering at the University of Illinois. In May, 1917, he resigned that office, after having completed 38 years of service in university work, to become president of the newly organized Railway Car Manufacturers' Association, an organization having as members some twenty-four railway-car manufacturing companies located throughout the country. In this capacity he handled important work for the car builders in connection with Government equipment business during the war and throughout the life of the Federal Railroad Administration, as well as many other matters of common interest to the car-building companies.

On August 1, 1925, Dr. Goss retired from active business and after that date resided at Barnstable, Mass., his birthplace.

Dr. Goss was given the honorary degree of Master of Arts by Wabash College in 1888, and the honorary degree of Doctor of Engineering by the University of Illinois in 1904. He was a member of the American Society for Testing Materials and of the Society for the Promotion of Engineering Education from their organization; a member of the Executive Committee of the National Advisory Board on Fuels and Structural Materials, of the Jury of Awards in the Transportation Department of the World's Fair of Chicago in 1893, of the Master Car Builders' Association, of the Master Mechanics' Association, of the Illinois Academy of Science, and of the Western Society of Engineers. He was a fellow of the American Society for the Advancement of Science, a member and past-president of the Western Railway Club, a member of the Railroad Club of New York, and also the Chairman of the Advisory Committee organized by the Pennsylvania Railway Company to direct its work in locomotive testing at the Louisiana Purchase Exposition. For many years he was a contributing editor to the *Railroad Gazette*. His contributions to technical literature were numerous. Probably his best-known work is that which deals with the locomotive. His books "Locomotive Performance" and "Locomotive Sparks" are records of personal researches which are known to most railroad men and to most students of locomotive design. Numerous researches conducted under the patronage of various associations are available only in the proceedings of these associations. Besides these, two noteworthy pieces of work were done under the patronage of the Carnegie Institution of Washington, the results of which were presented in two volumes, one entitled "High Steam Pressures in Locomotive Service," and the other, "Superheated Steam in Locomotive Service."

Gaetano Lanza

GAETANO LANZA, professor emeritus of theoretical and applied mechanics at the Massachusetts Institute of Technology, and since his retirement from that institution, consulting engineer to the Baldwin Locomotive Works, died on March 21, 1928, at his home in Philadelphia. For many years physically helpless, his mind had retained that keenness which helped bring mechanical engineering out of the field of empiricism in which he found it when he joined the Institute staff in 1871 into a more rational and scientific one.



Gaetano Lanza

His achievements in engineering education are briefly epitomized in an inscription on a tablet erected at the Institute in the entrance to the mechanical engineering department which reads:

THIS TABLET IS DEDICATED TO
PROFESSOR GAETANO LANZA
HEAD OF THE DEPARTMENT OF MECHANICAL ENGINEERING
1883–1911
UNDER WHOSE LEADERSHIP THE DEPARTMENT WAS DEVELOPED AND BY WHOSE FORESIGHT THE FIRST LABORATORY FOR TESTING FULL-SIZED STRUCTURAL SPECIMENS WAS ESTABLISHED.

Professor Lanza was born in Boston, September 26, 1848.

He was the son of Cavaliere Gaetano Lanza, of Palermo, Sicily, and Mary Ann (Paddock) Lanza, of Pomfret, Vt. His early schooling was at Charlottesville, Va., whither his family moved in 1859. He attended the University of Virginia, where he distinguished himself in mathematics, and from which he was graduated in 1870 with the degree of bachelor of science in civil and mechanical engineering.

After teaching at his alma mater for a year following graduation, he became an instructor of mathematics at the Massachusetts Institute of Technology. In 1872 he was appointed assistant professor, and, in 1875, professor of theoretical and applied mechanics, taking charge of the department of mechanical engineering in 1883, a position which he held until he was made an emeritus professor in 1911. He married Jennie Dice Miller, of Charlottesville, Va., in 1891.

Professor Lanza was an enthusiastic investigator throughout his life. His tests of timbers, framing joints, tile arches, reinforced concrete, locomotive connecting rods, springs, and his investigation of the balancing of high-speed machinery have been of great value to the profession. His publications, amounting to about one hundred, include his "Applied Mechanics" and his "Dynamics of Machinery."

He was a fellow of the American Academy of Arts and Sciences, and member of the following organizations: International Society for Testing Materials; Boston Society of Civil Engineers; American Mathematical Society, Society of Arts of the Massachusetts Institute of Technology; Appalachian Mountain Club; Society for the Promotion of Engineering Education; American Railway Master Mechanics' Association; Circolo Mathematico di Palermo; Societá Italiana per il Progresso delle Scienze; Public Art League; the Mathematical and Physical Club (composed of Harvard and Technology professors); and the Colonnade Club of the University of Virginia. He became a member of the A.S.M.E. in 1882. In 1907 he was decorated by the king of Italy as Cavaliere dell 'Ordine dei Sante Maurizio e Lazzaro.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Benjamin Garver Lamme—An Autobiography

BENJAMIN GARVER LAMME—AN AUTOBIOGRAPHY. G. P. Putnam's Sons, New York and London, 1926. Cloth, 6 × 9 in., 271 pp. portrait, illus., diagrams.

REVIEWED BY PAUL M. LINCOLN[1]

A MENTAL curiosity that will not be satisfied until it knows *why* is the predominating characteristic of those who become preeminent in any walk of life. This is particularly true of the engineer.

This platitude is brought to mind to a striking degree by a reading of B. G. Lamme's autobiography. The picture he gives us of his boyhood and youth indicates clearly that his mind had a bent toward engineering. His experiment in driving a spool at high speed shows this—first developing enough friction to set the spool afire and then, when he had remedied this difficulty, attaining a sufficient speed to burst the spool by centrifugal force. This boyish experiment of Lamme's is but one instance of his insatiable mental curiosity.

The same characteristic shows throughout his entire work. He didn't follow precedent; he made it.

Lamme was the first engineer to use the slotted armature for railway motors; the two-circuit or series winding for direct-current machines, the compensated field for alternators, the rotary converter, the equalizer connection—these were only a few of the innovations originated by Lamme in the early days.

In 1893 Lamme was called on to design the a.c. generators for the Niagara development—generators that were more than four times the capacity of anything that had been built up to that time. The fact that these self-same generators are still in service is evidence of his ability in carrying out the task.

Lamme tells about these things in an interesting and original way—in a way that still further emphasizes his insatiable mental curiosity.

Lamme and Steinmetz had much in common, and one such common interest was a love for weird stories. At Steinmetz' request, Lamme once made out a list of such books with his personal rating of each. To one interested in weird tales, this list alone is worth the price of the book.

But outstanding above everything else, the book gives a vivid picture of that insatiable mental curiosity that is always an indication of genius.

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The Laws of Cutting Metals

GRUNDZÜGE DER ZERSPANUNGSLEHRE (Fundamentals of the Theory of Metal Cutting), by Dr.-Ing. Max Kronenberg, Consulting Engineer. Julius Springer, Berlin, 1927. Cloth, 264 pp., 170 illus., 22.50 r.m.

REVIEWED BY JAMES A. HALL[2]

THE outstanding early attempts to deduce the laws of cutting metal were made in this country, but since the publications of Frederick W. Taylor and the contributions of Carl G. Barth in this connection and in the development of slide rules for the

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application of these laws to specific problems, comparatively little work has been done here to aid in solving the practical question of the proper speeds, feeds, and depths of cut to be used under different conditions. It is therefore of interest to find a foreign author reviewing all available research data on turning metal, and of greater interest that while but two American publications are quoted, those of Taylor and of French, Strauss, and Diggs, there are references to numerous German investigators of different phases of this problem, including the author himself, Friedrich, Hippler, Kurrein, Klopstock, Schlesinger, and others.

Throughout the volume the aim has been to put the conclusions in such shape that they will be of use to men in the shop, and it is noted in the preface that some research material has not been included because it was too complicated for practical application. This makes the book of particular value, and the author is to be commended for holding so consistently to this point of view.

Following a general introduction in the first chapter, the problem of cutting speed is discussed and then the laws of cutting pressure. In the fourth chapter these formulas for speed and pressure are combined to give equations for power required and work done, while the remainder of the book is devoted to applications of the relations previously derived.

Under the "Laws of Cutting Speed," the author first presents the type of equation given in "On the Art of Cutting Metals" for the relation between normal speed, feed, depth of cut, and radius of tool nose for a given tool life, and, after stating that this equation is altogether too complex to be used he proceeds to replot a considerable amount of Taylor's data and develop new formulas which can be more easily applied. In a series of articles starting in the September, 1919, issue of *Industrial Management*, Carl G. Barth points out that the Taylor equations were prepared by him as covering very closely the entire series of experiments on tool life. Much simpler formulas, which are sufficiently accurate for all practical purposes, were used in preparing the slide rules by which the laws of cutting were utilized, and these are given in Mr. Barth's articles. It is unfortunate that they were not included in the original treatise, as this would have relieved Taylor of much criticism similar to that of this author.

Dr. Kronenberg notes that practically all previous investigators of this problem have kept the feed and the depth of cut separate in their equations. He contends that they can be combined into one term, the chip cross-section, with reasonable accuracy, particularly if the German practice of using straight-sided in place of round-nose tools is followed. He then proceeds to replot all the available data on double cross-section paper and derive equations for tool life in the form

$$v = \frac{C_v}{\sqrt[e_v]{F}}$$

where v = cutting speed
F = chip cross-section
C_v = a constant varying with the machinability of the material, the composition of the tool, etc.

Recommending the straight-sided tool with its greater tendency to chatter may look to many American engineers like picking the tool suited to the equation rather than that best for the work.

Values of C_v and e_v are derived from the data of the different investigators for each of the materials tested, and some effort is made to evaluate the results so as to determine the most reliable figure.

The equations of normal cutting speed are given for some definite tool life, and must be corrected if a longer or shorter time is desired. For a constant chip section when cutting steel Taylor found that the tool life varied inversely as the eighth power of the velocity, while French, Strauss, and Digges make it the seventh power. On the other hand, the equations of a number of German investigators place this value at the third power. By some reasoning not entirely clear to the writer of this review, Dr. Kronenberg states that he has found that Taylor's "practical cutting speeds" more nearly correspond with the latter figure.

By the same methods as used in the study of cutting speeds, the laws of cutting pressure are determined, first in a general form and then taking into account the hardness of the material and the included angle of the cutting tool. Similarly an enormous amount of data of different investigators is analyzed, and constants and coefficients determined for various materials.

The laws of cutting speed and of cutting pressure are then combined to give formulas for the power required and work output. These are developed in terms of belt pull, strength of driving gears, stiffness of work being cut, etc.

The method of applying these equations to individual machines is then discussed, and a new type of lathe instruction sheet or table is advocated. Instead of the general and rather indefinite recommendations generally given, such sheets would have the above laws so applied to the particular machine that the best speed, feed, etc. for any job could be determined almost immediately. These would fill the same place as have Barth's slide rules in many places in this country, and an interesting study might be made of the relative merits of the two systems.

It has frequently seemed desirable that such instruction diagrams or slide rules be furnished by machine-tool builders with their machines, but the general feeling has been that there were not sufficient data available to make the idea practical. Serious consideration should be given to the fact that this practice is now being seriously advocated in Germany, and that the research work to make the development possible has been done largely by their own investigators.

The last chapter includes a complete summary of the equations developed in the earlier sections, and gives tables of recommended constants and coefficients to be used for different materials. The information is in such shape that it can be applied directly to actual turning problems or checked against experimental data. As a result the accuracy of the conclusion and of the constants, when applied to American working conditions, should be readily determined.

Dr. Kronenberg is to be congradulated for collecting so much of the available data on metal turning and for attempting to reduce it to such simple form that it can be put to practical use. Even if future testing of his conclusions should show that the simplification was carried further than is warranted, this work will still be an outstanding contribution to the ultimate solution of the problem.

Books Received in the Library

BEITRÄGE ZUR GESCHICHTE DER TECHNIK UND INDUSTRIE; Jahrbuch des Vereines Deutscher Ingenieure. Vol. 17, 1927. Edited by Conrad Matschoss. V.D.I. Verlag, Berlin, 1927. Cloth, 9 × 12 in., 180 pp., illus., 16 r.m.

In order to make this yearbook less expensive its format and type have been changed to those used for other publications of the Society of German Engineers. The result is less pleasing to the eye, but the contents maintain the high level of previous years, and the set is indispensable to any student of engineering history.

The historical essays include articles on the cylinder printing press, spectacles, high-frequency engineering, insulators for aerial conductors, spinning and weaving, cylinder boring mills, and

early railroad accidents. A biography of Volta is included, and a Venetian patent to Galileo is reproduced. A fully illustrated article on the engineering memorials of Germany contains many interesting examples of early work. A review of the year and a bibliography conclude the book.

Beitrag zur Beurteilung von Temperaturfeld und Wärmespannungen in Mechanisch Abgebremsten Scheiben. By K. Requa. (Forschungsarbeiten auf dem Gebiete des Ingenieurwesens No. 301.) V.D.I. Verlag, Berlin, 1928. Paper, 8 × 12 in., 13 pp., tables, 2.50 r.m.

A mathematical investigation of the temperatures produced when mechanical brakes act upon large high-speed drums, and of the stresses which these temperatures cause. The calculations are illustrated by application to an Ilgner drum.

Beitrag zur Mengenmessung Strömenden Dampfes Mittels Stauringen. By Walter Pflaum. V.D.I. Verlag, Berlin, 1928. (Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, heft 298.) Paper, 9 × 12 in., 41 pp., illus., tables, 5 r.m.

This research, carried out at the mechanical laboratory of the Dresden Technical Institute, was undertaken to ascertain the conditions under which orifice meters are accurate for measuring the flow of steam, and the effect of various sizes of orifices and pipes and methods of measuring pressure upon the results. The relations between the amount of steam and the size of orifice, static and differential pressure, etc., were studied thoroughly.

Der Einfluss der Dampftemperatur auf den Wirkungsgrad von Dampfturbinen. By Arthur Zinzen. J. Springer, Berlin, 1928. Paper, 6 × 9 in., 67 pp., diagrams, 6 r.m.

An elaborate theoretical and experimental investigation of the influence of the temperature of the steam upon the efficiency of steam turbines. After developing the theory mathematically, the author subjected it to practical tests, and draws his final conclusions from both. His experiments did not confirm the theory of undercooling advanced by Martin and others.

Englands Industrie am Scheidewege. By W. Müller. V.D.I. Verlag, Berlin, 1928. Paper, 6 × 8 in., 182 pp., illus., tables, 6.80 r.m.

In this social, economic, and political study of English industry, the author endeavors to give the German industrialist an intimate view of the conditions affecting one of his chief competitors in the world market, and of the ways in which England is meeting the problems that confront it. The economic position of England is compared with that of the United States and Germany. The ways in which industry and commerce are being organized and controlled are set forth, and the relations between capital and labor are discussed.

English for Engineers. By S. A. Harbarger. Second edition. McGraw-Hill Book Co., New York, 1928. Cloth, 5 × 7 in., 300 pp., $2.

This book treats of English as a tool for transmitting thought, and is planned to aid the engineer in acquiring skill in its use as a professional aid. It takes up first letters of application, telegrams, orders, inquiries, and instructions, and the sales letters, which engineers must write; and then proceeds to more formal writing for publication. The advice given is sound and concise. There are numerous references for collateral reading, and the cultural value of general reading is not forgotten.

Harvard Business Reports, Vol. 4. By Graduate School of Business Administration, George F. Baker Foundation, Harvard University. A. W. Shaw Co., Chicago and New York, 1927. Cloth, 6 × 9 in., 559 pp., $7.50.

A collection of cases dealing with administrative aspects of the relations between labor and employer. These cases illustrate current operating issues, the channels through which such issues are negotiated, and problems arising from those relationships between employer and employee which are superimposed upon the labor relationship. The cases are reported in full, with commentaries upon the decisions. They form a useful collection of reference material for the executive.

"Hütte"—des Ingenieurs Taschenbuch, Vol. 4. Twenty-fifth edition. By Akademischen Verein Hütte, E. V. in Berlin. Wilhelm Ernst & Sohn, Berlin, 1927. Cloth, 5 × 8 in., 864 pp., illus., diagrams, tables, 18 r.m.

This volume covers a number of topics which have not been cared for in previous editions of Hütte. It is intended to supply the mechanical engineer with the information of value to him on the mechanical technology of raw materials and articles of commerce which he uses in constructing and operating machinery. Processes of manufacture, properties, standards of quality, usual commercial varieties, and efficiencies are given for materials and machines.

Among the topics treated are naval and marine engineering, automotive engineering, mining and milling, agriculture, foods, forestry, tanning, paper and textiles, ceramics, gas, printing, cinematography, radio, and packing.

Motor Traffic Management. By G. Lloyd Wilson. D. Appleton & Co., New York, 1928. (Transportation Series.) Cloth, 6 × 9 in., 251 pp., charts, graphs, $3.

The author has been engaged for three years, he states, in collecting data dealing with traffic problems of motor-bus and truck operators and in attempting to apply to these problems the principles of traffic management which have been evolved through the application of economic fundamentals to railroad, express, and steamship business. He here presents the results of his labors.

The New Reformation: From Physical to Spiritual Realities. By Michael Pupin. Charles Scribner's Sons, New York, 1928. Cloth, 5 × 8 in., 273 pp., portraits, $2.50.

The essays in this book, originally prepared for popular lectures, are intended to give persons without elaborate scientific training an understanding of the close relationship between the several physical realities which science has disclosed during the last four hundred years. Dr. Pupin hopes that a better understanding of them will hasten recognition of the relationship between physical and spiritual realities, and of the absence of any conflict between science and religion.

Physics in Industry; Lectures delivered before the Institute of Physics, vol. 5. Relation of Physics to Aeronautical Science, by H. E. Wimperis; and Physics in Navigation, by F. E. Smith. Humphrey Milford, Oxford University Press; London, 1927. Boards, 6 × 10 in., 54 pp., illus., 2s. 6d.

The two lectures printed in this volume deal respectively with the relationship of physics to aeronautical science and with physics in navigation. The lectures are popular in style. They are intended to illustrate the help extended by physicists to workers in those fields, and to call attention to problems requiring cooperative investigation.

Die Wassersperrarbeiten bei Bohrungen auf Erdöl. By B. Schweiger. Julius Springer, Berlin, 1928. Paper, 7 × 10 in., 107 pp., illus., 9 r.m.

An attempt to describe fully and systematically all the methods in use for excluding water from oil wells, and to give a critical estimate of the usefulness of each. The author has had practical experience in Galicia, the East Indies, and Mexico, and has also examined the literature on the subject. The book is the only special text on the subject.

Synopses of A.S.M.E. Spring Meeting Papers

THE papers abstracted on this and the following pages are being printed in full in pamphlet form for the Spring Meeting. Copies of them may be secured by filling out the blank on page 421 of this issue of MECHANICAL ENGINEERING and mailing it to the office of the Society. The program for the Spring Meeting appears on page 422 of this issue.

Ball-Bearing Machine-Tool Spindles

By THOMAS BARISH

Assistant Chief Engineer, Gurney Division, Marlin-Rockwell Corporation, Jamestown, N. Y.

THIS paper is a review of the three types of ball-bearing machine-tool spindles now in use, showing how rigidity is obtained in each type and what results have been obtained. There is also a historical review of the first type, which was originally put into service over ten years ago and has since received minor improvements. The three main groups are: (*a*) Two-bearing, manually adjusted spindles; (*b*) automatically spring-adjusted spindles; and (*c*) three-bearing spindles, adjustable and non-adjustable. Comparisons are made between the various types for their rigidity, and some deflection curves and actual measurements of rigidity are quoted.

Training Minor Executives in a Rapidly Growing Organization

By A. J. BEATTY

Director of Training, The American Rolling Mill Co., Jamestown, Ohio

IN THIS paper the author discusses the problem of maintaining a trained working force in a rapidly expanding organization. The problem of the American Rolling Mill Company is used as an illustration of what may be accomplished through proper attention to the requirements of an expanding company and the material available in the existing personnel. Two courses organized to replace the old Works' School of the company namely, the Operating Training Course and the Sales Apprentice Course, are described. Other means of meeting new issues in the most effective manner are presented in the author's discussion of the Foreman's Cabinet and the Foreman's Forum, the former serving in an advisory capacity and the latter as an outlet to discussion.

Education and Training as Applied to the Engineer

By F. L. BISHOP

Secretary, Society for the Promotion of Engineering Education, Pittsburgh, Pa.

AS THE author sees it, the two important problems confronting engineering education today are (1) the continuation of the graduate's education in the immediate years after leaving college when he is going through the process of orienting himself to his profession, and (2) the selection, preparation, and development of the younger teachers in the engineering schools. As an illustration of the organized effort to provide such graduate work he describes in some detail the arrangement existing between the University of Pittsburgh and the Westinghouse Electric and Manufacturing Company. He then touches briefly on the increasing difficulty that is being experienced in enlisting and holding able and inspiring men in the teaching ranks, and urges action to meet this situation before a more critical one arises.

Some Economic Factors in Power-Station Design

By H. BOYD BRYDON

Mechanical Engineer, Byllesby Engineering and Management Corp., Chicago, Ill. Mem. A.S.M.E.

AFTER a discussion of capacity factors and average loads of steam turbines over a sixteen-year life period, the author examines the costs of seven 60,000-kw. unit plants. Of these, one is to operate with steam at 400 lb. pressure, three with steam at 600 lb., and three with steam at 1200 lb., there being different reheating arrangements provided in the 600-lb. and 1200-lb. plants. Preliminary layouts of the 400-lb., 600-lb., and 1200-lb. plants are shown. It is concluded that the adoption of the 400-lb. plant is preferable on the score of simplicity, ease of operation, and cost. Should conditions ever arise under which the use of a pressure of 1200 or 1500 lb. may become attractive, the proposed pressure will fit in nicely. The 600-lb. plant will not.

Combination Firing of Blast-Furnace Gas and Pulverized Coal

By F. G. CUTLER

Chief of Bureau of Steam Engineering, Tennessee Coal, Iron & R.R. Co., Ensley, Ala. Mem. A.S.M.E.

THE Ensley blast-furnace plant of the Tennessee Coal, Iron & Railroad Company, consisting of six blast furnaces, has been operating for about five years a boiler plant using pulverized coal to supplement blast-furnace-gas firing. Particulars regarding the installation and the results obtained therefrom form the subject-matter of the paper. It is stated that the comparative operating costs for fuel as well as for producing labor and for repairs and maintenance are materially lower than before, and that the installation is considered to have been very successful.

Some Common Delusions Concerning Depreciation

By ERNEST F. DuBRUL

General Manager, National Machine Tool Builders' Association, Cincinnati, Ohio. Assoc. A.S.M.E.

THIS paper points out the effect of inflation of currency in creating illusions as to depreciation accounting. It shows the fallacy of usual accounting practice that takes into cost a depreciation allowance based on the original cost of fixed assets; and the necessity of calibrating the dollar measure of value consumed during each period, to allow for changes in the purchasing power of the dollar; and how the present common practice results in overstatement of real profits by understatement of actual depreciation in some cases, and vice versa in others.

The author shows graphically the difference between dollar accounts that are uncalibrated and those that are calibrated for purchasing power. He uses the depreciation and net profits reported by the U.S. Steel Corporation to illustrate the point.

A Study of Tin-Base Bearing Metals

By O. W. ELLIS and G. B. KARELITZ

Respectively with Research Department and Research Engineer (Mem. A.S.M.E.) of the Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

THIS study represents the first part of an investigation of babbitts. It comprises the results of metallographic and mechanical tests on a series of tin-antimony-copper alloys containing up to 10 per cent of antimony and 8 per cent of copper. Relationships between the composition, microstructure, hardness, and compressive strength of these alloys are given, and the influence of elevated temperatures and of lead upon these properties are recorded.

Computation of the Tail-Water Depth of the Hydraulic Jump in Sloping Flumes

By ROBERT W. ELLMS

Cleveland, Ohio. Jun. A.S.M.E.

THIS investigation deals primarily with the methods of computing the tail-water depth of the hydraulic jump when it is produced in sloping flumes. The author has developed two formulas for this calculation based upon the unpublished work of A. G. Levy and J. W. Ellms of the Cleveland Water Department, and of J. R. Fleming and the author in a thesis presented to Case School of Applied Science. In this paper are given a description and the data of the latter's thesis work, and certain data obtained by the two former investigators. From a study of the results of these experiments the author has drawn certain conclusions as to what takes place in the hydraulic jump when it is produced in sloping flumes, and attempts an explanation of this spectacular and baffling phenomenon.

A Materials-Handling and Transport Organization

By C. A. FIKE

Supervisor of Transportation, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

THIS paper outlines briefly the organization which has in charge the materials-handling activities of the Westinghouse Elec. & Mfg. Co. at East Pittsburgh. It describes the equipment used, its operation, and the methods of its control, as well as several of the wage-incentive plans which are used in the payment of the employees of the Works Transportation Department. The paper concludes with a statement of some of the economies resulting from the organization described.

Some Recent Improvements in the Manufacture of Flat Glass

By H. K. HITCHCOCK

Consulting Engineer, Pittsburgh Plate Glass Company, Pittsburgh, Pa.

THE object of this paper is to touch on the early methods of making sheet glass, point out the generally accepted methods used, and briefly outline the most recent developments in the industry, giving references to the literature on the subject so that those interested in it may be able to get in touch with the general line of this development without exhaustive search.

The paper deals first with the primitive, hand-operated ways of producing flat glass by spinning, blowing, and casting; the development of the use of power-driven machinery in casting, blowing, and drawing; and finally with the development of the continuous method of casting from tanks and grinding and polishing, with a brief description of an improved method of casting from pots.

The Use of Pulverized Coal in Basic Open-Hearth Furnaces

By E. L. HERNDON

Receiver, The Eastern Steel Co., Pottsville, Pa.

THE experience of The Eastern Steel Company with pulverized coal as fuel for basic open-hearth furnaces was anything but voluntary. The company had been very happily using oil which was low in price and high in quality when the price of this fuel began to rise and continued until it was necessary to cease using it. Since then, for thirteen years, the company has continuously wrestled with the problems arising in the development of a little-known fuel. At times it has been more than willing to abandon the entire plan. Very little working knowledge was gained before the war period, and during the war costs were of less consequence than ordinarily. After that period passed, however willing the company was to alter the design of the furnace and change the fuel, the necessary capital was never available. After many tribulations and at times successive disappointments, some understanding of the subject has been reached, and it is believed that pulverized coal is the best fuel for conditions as they exist. It is not recommended on that account, however, that others adopt pulverized coal until a thorough examination of each situation has been made.

Torsional Stress Distribution in Prismatical Bars

By LYDIK S. JACOBSEN

Assistant Professor of Mechanical Engineering, Leland Stanford Junior University, Stanford University, Calif.

IN THIS paper an attempt to show that the torsional stress at a point in a prismatical bar is mathematically analogous to the potential gradient at a similarly located point in an electrical plate conductor if:

(a) The geometric outline of the conductor in the Y-Z plane be similar to the geometric outline of the cross-section of the bar, the center of twist of the bar coinciding with the origin of the Y-Z axes;

(b) The specific electrical conductivity of the conductor be proportional to the fourth power of the distance from the center of twist, or from the Y-Z origin; and

(c) The potential gradient be multiplied by the square of the distance of the point from the origin.

In addition to the theoretical work, experiments relating to the theory have been carried out for a number of different sections, all of which have doubly connected boundaries.

Industrial Cooperation in Education

By A. C. JEWETT

Director, College of Industries, Carnegie Institute of Technology, Pittsburgh, Pa. Mem. A.S.M.E.

THIS paper indicates the need of more training and education for all employees, including the semi-skilled and unskilled.

It points out that this can be effectively and inexpensively obtained. Data are given pertaining to night-school instruction in the Pittsburgh district.

The Flow of Heat Through Furnace Hearths

By J. D. KELLER, EAST PITTSBURGH, PA.

IN THIS paper the author points out the lack of satisfactory charts upon which the engineer in the past has been able to base calculations of heat flow through furnace hearths as he has been accustomed to using them in the calculation of flows through furnace walls. The solid or non-ventilated type is discussed and certain conclusions as to relations of shape and construction to heat flow are reached. The greater part of the paper is devoted to explanation of the methods used in arriving at these conclusions. A series of formulas and examples, illustrating their use, is given for each of the several types of furnaces discussed.

Systems of Workman Payment in Porcelain Factories

By HOBART M. KRANER

Westinghouse Research Laboratory, East Pittsburgh, Pa.

THIS paper describes the application of Standard Time and several other incentive systems as applied specifically to an electric porcelain plant. It points out the necessity of detailed study of the various operations in determining the applicability of the systems to these operations. It also points out the disadvantages of the simple piece-work system so much used in porcelain plants where Standard Time and other such wage-payment plans have not been studied.

Stresses in the Drive System of Three-Cylinder Locomotives

By FRITZ LOEWENBERG

American Locomotive Company, Schenectady, N. Y.

IN THIS paper the author analyzes the stresses set up in the side rods and driving axles of three-cylinder locomotives of the type in which all cylinders act upon the same axle, taking into consideration the small inaccuracies of fittings resulting in clearances and play, and the elastic deformations produced. Formulas are derived and their application is illustrated by means of numerical calculations. Systems with more than two axles are also considered.

The Theory of the Dynamic Vibration Absorber

By J. ORMONDROYD and J. P. DEN HARTOG

Respectively with Motor Engineering Department and with Power Engineering Department, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

THE "vibration absorber" discussed in this paper consists of a small vibratory system tuned to the operating frequency of a larger machine and attached to it in a suitable location. When properly designed this will reduce the vibrations of the machine itself materially. The absorber, without damping, annihilates vibrations of its own frequency completely, but creates two other critical speeds in the machine system. Therefore it is suitable only for application on constant-speed machinery. When damping is introduced into the absorber it constitutes a simple and efficient means of diminishing the vibrations of a machine of variable speed. In the paper an analysis of its operation in simple cases with and without damping is given, tests made on a model are described, and actual applications are discussed.

High-Pressure Steam Boilers

By GEO. A. ORROK

Consulting Engineer, The New York Edison Company, New York City. Mem. A.S.M.E.

AFTER briefly referring to the work of Münzinger, Hartmann, and Mellanby and Kerr, the author proceeds to discuss the lines of further investigation which to him seem to offer the most promise. In so doing he discusses the effect of tube inclination; the circulation problem; releasing surface and steam space; safety in operation; increase in capacity; boiler materials; temperature margins; and stresses in superheater tubes, riveted drums, and headers. Among other things, it is brought out by this discussion that (1) a high-pressure boiler must consist largely of banks of tubes; (2) that headers in great variety are available up to at least 1400 lb. pressure; (3) that drums must be of small diameter and should not contain over 10 per cent of the water content of the boiler; (4) that below 1000 lb. there is no need of employing alloy steels, but above that pressure such steels are available and should be used if the temperature margins so require; (5) that for superheats higher than 800 deg., alloy steels are indicated; (6) that 20 or more different designs of boilers are successfully operating at pressures of 500 lb. and over, six at 1000 lb., and one at 2000 and over; and (7) that enough work has been done to show that their efficiencies are comparable to those obtained with boilers of lower pressure. In closing, the author states his conclusions as to the type of high-pressure boiler best suited to present limitations.

Locomotive and Freight-Car Utilization

By C. B. PECK

Managing Editor, *Railway Mechanical Engineer*, New York. Assoc-Mem. A.S.M.E.

SINCE the termination of Federal control in 1920 the railroads, although car loadings have decreased, have nevertheless through promptness of movement rendered a progressively improving service to the public. The author gives both tabular and charted data on car and locomotive performance, both freight and passenger, and presents a study of what the more effective utilization of equipment means to the railroads themselves, what tendencies it has set in motion, and how they are likely to affect the future.

Plate-Steel Rotor for an Electric Generator

By H. G. REIST

Designing Engineer, Alternating-Current Machinery, General Electric Co., Schenectady, N. Y. Mem. A.S.M.E.

THIS paper explains in brief the construction of a 220-ton revolving-field spider for a generator driven by a vertical water wheel. In designing this spider the object was to obtain a construction having the least waste of material, ample strength, the fewest unknown quantities, and one which could be economically produced by existing shop equipment.

Power Brakes and Modern Train Operation

By L. K. SILLCOX

Assistant to President, New York Air Brake Co., Watertown, N. Y. Mem. A.S.M.E.

THE paper presents a historical résumé of the development of the air brake, including a description of the Eames vacuum brake. Details of important features of air-brake equipment are illustrated. Appendixes to the paper includes a glossary

of air-brake terms and engineering data on the fundamental was governing retardation.

The Manufacture of Seamless Tubes

By R. C. STIEFEL and GEORGE A. PUGH

Respectively Consulting Engineer and Vice-President and Assistant Vice-President, Aetna-Standard Engineering Co., Youngstown, Ohio.

TWO methods are today available in the manufacture of seamless tubes of 4 in. and greater diameter. These are the pilger process and the automatic or plug-mill process. The cost of installation is about the same for either process. The cost of tool equipment is much greater for the pilger process and it is claimed that the quality of the tube, particularly in the matter of service, is more uniformly reliable with the plug-rolling process than with the pilger process.

Referring particularly to the plug-rolling process, the authors discuss the difficulties of operation and modern improvements aimed at obviating these difficulties. A distinction is emphasized between the part of the billet affected, or as the authors style it, "explored," by the mandrel, and the part which is unexplored, and the smaller the unexplored section is in relation to the full section of the solid billet, the fewer are the defects on the inside of the pierced tube. This leads to the conclusion that for the production of a given size of tube as small a solid billet as possible should be used. This is proved by a formula given for power consumption in piercing. The design of piercing mills is next considered from the same point of view, and the most recent developments in the use of expanding mills are described.

A Water-Level Gage of the Long-Distance Recording Type

By E. B. STROWGER

Assistant Hydraulic Engineer, Niagara Falls Power Company, Niagara Falls, N. Y.

THIS paper describes a water-level gage of the long-distance recording type, consisting essentially of two Selsyn motors, one called the transmitter and one the follower, together with a float and a recording device. The transmitter is located at the point of measurement and the follower at some central point where the record is to appear. The position of the rotor of the transmitter is controlled by a float. The follower motor operates a pen carriage which records on a paper with suitable scaled divisions. The motors are essentially induction motors with wound rotors excited from a common alternating-current source. The rotor of the follower will follow the transmitter rotor due to the induced currents in the stators.

Mechanical Properties of Aluminum Casting Alloys at Elevated Temperatures

By R. L. TEMPLIN, C. BRAGLIO, and K. MARSH

Respectively Chief Engineer of Tests, Testing Engineer, and Chief of Pyrometric Division, Aluminum Company of America, Pittsburgh, Pa.

THE investigational work described in Part I of this paper includes tensile results obtained from "short-time" high-temperature tests of ten different aluminum casting alloys and very pure cast aluminum, and for various heat treatments in the case of some of the alloys. All the specimens tested were sand cast and include the more common commercial casting alloys of aluminum.

Data are presented to show how certain effects of temperature on aluminum alloys susceptible to heat treatment may be appreciably modified by still further heat treatment or artificial aging. A method is indicated for applying experimental results from a single lot of specimens to commercial-product average values, together with a complete table of recommended tensile-property values at various temperatures for the alloys tested.

The second part of the paper describes the original heating equipment; the alternate tests and alterations to equipment to determine and improve the temperature uniformity throughout the specimen; also the method of measuring the specimen temperatures during tensile tests, data being presented to substantiate the reliability of this method.

Locomotive Sparks

By L. W. WALLACE

Executive Secretary American Engineering Council, Washington, D. C. Mem. A.S.M.E.

THE annual loss due to fires alleged to have been started by locomotive sparks is stated in the paper to be approximately 12 million dollars. Numerous locomotive and laboratory tests have been made for the purpose of determining the behavior of such sparks, and the author presents some of the findings relating to the subject. It is his belief that under the most favorable circumstances it is very unlikely that a spark of sufficient size and temperature ever reaches the ground in a condition that will ignite even the most inflammable material beyond 65 ft. from the center of the track. He is of the opinion that sufficient data have now been accumulated from which fixed laws relating to the behavior of locomotive sparks may be formulated.

The Reciprocating Dry-Vacuum Pump

By WALTER S. WEEKS and PIERRE E. LETCHWORTH

Department of Mining and Metallurgy, University of California, Berkeley, Calif.

THIS paper is concerned with the number of strokes that must be made by a pump to produce a given pressure in a tank. The theory of a vacuum pump with clearance is presented, and a formula is derived which gives the requisite number of strokes and which involves the dead-end vacuum expressed as a fraction of a perfect vacuum, the vacuum after n strokes expressed in the same manner, and a factor which involves the volume of the tank, the displacement of the pump, and its clearance. Experiments were carried on by the authors to test the accuracy of their formula, and the causes for deviation are discussed in the paper.

The Strength of Steel Columns

By H. B. WESTERGAARD and WM. R. OSGOOD

Respectively Professor of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill., and Assistant Professor of Structural Engineering, Cornell University, Ithaca, N. Y.

THE object of the investigation described in this paper is to determine the maximum load for the shorter or medium-long column by theoretical analysis, the method used being based on the same principles as were used by Kármán and being applicable to columns of any shapes of cross-section. It results in three sets of curves which show the relation between the slenderness ratio and average stress for steel columns of rectangular cross-section, the first being for straight, pin-ended columns with various eccentricities of the load, and the other two for initially curved, pin-ended columns having various degrees of initial curvature.

A.S.M.E. Spring Meeting Papers Available

(1) Barish, Thos., Ball-Bearing Machine-Tool Spindles
(2) Beatty, A. J., Training Minor Executives in a Rapidly Growing Organization
(3) Bishop, F. L., Education and Training as Applied to the Engineer
(4) Brydon, H. B., Some Economic Factors in Power-Station Design
(5) Cutler, F. G., Combination Firing of Blast-Furnace Gas and Pulverized Coal
(6) DuBrul, E. F., Some Common Delusions Concerning Depreciation
(7) Ellis, O. W., and Karelitz, G. B., A Study of Tin-Base Bearing Metals, Part I
(8) Ellms, R. W., Computation of the Tail-Water Depth of the Hydraulic Jump in Sloping Flumes
(9) Fike, C. A., A Material-Handling and Transport Organization
(10) Herndon, E. L., Use of Pulverized Coal in Basic Open-Hearth Furnaces
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(15) Kraner, H. N., Systems of Workman Payment in Porcelain Factories
(16) Loewenberg, F., Stresses in the Drive System of Three-Cylinder Locomotives
(17) Ormondroyd, J., and DenHartog, J. P., The Theory of the Dynamic Vibration Absorber
(18) Orrok, G. A., High-Pressure Steam Boilers
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(22) Stiefel, R. C., and Pugh, G. A., The Manufacture of Seamless Tubes
(23) Strowger, E. B., A Water-Level Gage of the Long-Distance Recording Type
(24) Templin, R. L., Braglio, C., and Marsh, K., Mechanical Properties of Aluminum Casting Alloys at Elevated Temperatures
(25) Wallace, L. W., Locomotive Sparks
(26) Weeks, W. S., and Letchworth, P. E., Reciprocating Dry-Vacuum Pumps
(27) Westergaard, H. M., and Osgood, W. R., Theory of Strength of Steel Columns

The papers, listed above, to be presented at the Pittsburgh Spring Meeting, will be available in pamphlet form and may be secured without cost by any member of the Society.

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A.S.M.E. Spring Meeting Program

Pittsburgh, Pa., May 14-17, 1928

Monday, May 14

Morning: 9:30 A.M.
Council Meeting
Conference of Local Sections' Delegates

Afternoon: 2:00 P.M.
Council Meeting
Business Meeting, 4:30 P.M.

Afternoon: Simultaneous Sessions: 2:30 P.M.

Fuels and Heat Flow

Auspices of Fuels, Iron and Steel, and Steam Power Divisions

The Flow of Heat Through Furnace Hearths, J. D. KELLER.
Use of Pulverized Coal in Basic Open-Hearth Furnaces, E. L. HERNDON.
Combination Firing of Blast-Furnace Gas and Pulverized Coal, F. G. CUTLER.

Management

Jointly with Pittsburgh Section, American Ceramic Society

Systems of Workman Payment in Porcelain Factories, H. N. KRANER.

General

Reciprocating Dry-Vacuum Pump, W. S. WEEKS and P. E. LETCHWORTH.
Plate-Steel Rotor Design for an Electric Generator, H. G. REIST.

Education and Training for Industries

Training Minor Executives in a Rapidly Growing Organization, A. J. BEATTY.

Tuesday, May 15

Morning: Simultaneous Sessions: 9:30 A.M.

Seamless Tubing

Auspices of Iron and Steel Division

The Manufacture of Seamless Tubes, R. C. STIEFEL and GEORGE A. PUGH.

Railroad

Locomotive and Freight-Car Utilization, C. B. PECK.
Power Brakes and Modern Train Operation, L. K. SILLCOX.
Locomotive Sparks, L. W. WALLACE (by title).

Hydraulic

A Water-Level Gage of the Long-Distance Recording Type, E. B. STROWGER.
Computation of the Tail-Water Depth of the Hydraulic Jump in Sloping Flumes, ROBERT W. ELLMS.

Wednesday, May 16

Morning: Simultaneous Sessions: 9:30 A.M.

Student Branch Conference

Machine-Shop Practice

Some Common Delusions Concerning Depreciation, ERNEST F. DUBRUL.
Ball-Bearing Machine-Tool Spindles, THOS. BARISH.

Applied Mechanics

The Theory of the Dynamic Vibration Absorber, J. ORMONDROYD and J. P. DENHARTOG.
Theory of Strength of Steel Columns, H. M. WESTERGAARD and W. R. OSGOOD.

Glass

Some Recent Improvements in the Manufacture of Flat Glass, H. L. HITCHCOCK.

Engineering Education

Industrial Cooperation in Education, A. T. JEWETT.
Education and Training as Applied to the Engineer, F. L. BISHOP.

Thursday, May 17

Morning: Simultaneous Sessions: 9:30 A.M.

Materials Handling, Jointly with Management

A Material-Handling and Transport Organization, C. A. FIKE.

Alloys

Mechanical Properties of Aluminum Casting Alloys at Elevated Temperatures, R. L. TEMPLIN, C. BRAGLIO, and K. MARSH.
A Study of Tin-Base Bearing Metals, Part I, O. W. ELLIS and G. B. KARELITZ.

Central-Station Power

Some Economic Factors in Power-Station Design, H. B. BRYDON.
High-Pressure Steam Boilers, GEO. A. ORROK.

Applied Mechanics

Torsional Stress Distributions in Prismatical Bars, L. S. JACOBSEN.
Stresses in the Drive System of Three-Cylinder Locomotives, F. LOEWENBERG.

Entertainment Events, Excursions, etc.

Monday, May 14, *Evening:*
Informal Entertainment.

Tuesday, May 15, *Afternoon:*
Inspection Trip: Train ride through plants of the U.S. Steel Corporation.

Wednesday, May 15, *Afternoon:*
Student-Branch Luncheon, 2 P.M.
Inspection Trip: Westinghouse Electric and Manufacturing Co.
Evening: Dinner and award of Holley Medal to E. A. SPERRY.

Thursday, May 17, *Afternoon:*
Inspection Trip: American Window Glass Co., Jeannette, Pa.